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electronic bloodspot detection in commercial egg grading

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MARKETING RESEARCH REPORT 239
MARKETING RESEARCH DIVISION
AGRICULTURAL MARKETING SERVICE
U.S. DEPARTMENT OF AGRICULTURE

PREFACE

This report is based upon research in the problem of integrating the recently developed electronic bloodspot detector into a commercial egg grading line and is the first part of a study in the mechanization of the egg grading and packing operation. As this report is being completed, trial modifications of the experimental line developed for the study are already being tested under industry conditions. Simplification of egg position patterns at the egg packaging stations indicate the possibility of sizable further savings in packing labor. When further equipment modifications and development are completed, tests will be conducted, and findings analyzed, evaluated, and published as a second part of the study in mechanization of the egg grading and packing operation.

The study was conducted in San Diego, Calif., and is a part of a larger research project covering the development of improved work methods, devices, equipment, and related facilities for the off-farm conditioning, handling, storage, preparation for market, and marketing of shell eggs. It was conducted jointly by the Transportation and Facilities Branch, Market Organization and Costs Branch, and the Biological Sciences Branch, of the Marketing Research Division, Agricultural Marketing Service, U. S. Department of Agriculture.

Norris T. Pritchard, Market Organization and Costs Branch; Fred C. Winter, Professor of Industrial Engineering, Columbia University, and consulting engineer, Transportation and Facilities Branch; Karl H. Norris, Biological Sciences Branch; and Dr. A. W. Brant, Agricultural Research Service, provided technical assistance.

The San Diego Co-Operative Poultry Association provided eggs and furnished facilities and grading and packing labor for trial runs and test purposes.

Food Systems, Inc., Oakland, Calif., and Librascope Inc., Santa Ana, Calif., furnished the electronic detector and the service on it during the tests.

Harry E. Drews, Chicago, Ill., constructed the experimental grading line.

Dr. George F. Stewart, University of California, developed the procedure and analysis of the broken-out tests.

Poultry Division, Agricultural Marketing Service, graded the eggs for quality.

Dr. Cora Miller and Lynn Sanborn, University of California at Los Angeles, examined the broken-out eggs for bloodspots.

Washington, D. C. June 1958

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SUMMARY

A recently developed electronic device detects and removes eggs containing bloodspots at a rate of 7,200 eggs per hour, and does it more accurately than can be done by hand. When manual grading of high quality eggs (80 to 100 percent A) is replaced by electronic bloodspot detection preceded by flash candling, industry can save 3 cents a case in grading costs.

This saving results primarily from elimination of the costs of manual grading. If manual grading of individual eggs were added to flash candling and use of the bloodspot detector, there would be a total added cost of 13 cents per case above the costs of traditional methods. When 60 to 80 percent A quality is involved in the same grading method the added costs per case are 5 cents.

The total costs per case for grading and packing white eggs by either candling each egg and/or flash candling while employing electronic detection of bloodspots compare with the costs of the entirely manual operation as follows:

1. Electronic detection and mechanical removal of eggs containing bloodspots and flash candling with the candling of individual eggs omitted:

Quality of eggs	Cost per case
60 to 80 percent A quality	Not evaluated
80 to 100 percent A quality.	43¢

2. Human detection and manual removal of eggs containing bloodspots while candling each egg for quality:

60 to 80 percent A quality	57¢
80 to 100 percent A quality.	46¢

3. Electronic detection and mechanical removal of eggs containing bloodspots, flash candling and also candling each egg for quality:

60 to 80 percent A quality	62¢
80 to 100 percent A quality.	59¢

The study involved approximately 3,400 time study readings, inspection of all eggs for grader accuracy and analysis of labor and equipment cost during the time 100 cases of eggs (36,000 eggs) were being graded and packed.

The regular commercial grading system in operation in the plant was carefully studied during the time that the two egg qualities selected for study (60 to 80 and 80 to 100 percent A quality) were being graded and packed. The results were analyzed and evaluated.

An experimental grading line was developed to replicate the layout of the regular commercial line with provision for electronic detection preceded by flash candling. The latter was for the purpose of removing opaque bloods that are not rejected by the detector and for the purpose of detecting and removing eggs with cracked shells that might not withstand extensive automatic handling. After construction and installation in the plant the experimental line was tested under operating conditions similar to those prevailing during the tests of the commercial line. The findings were analyzed and evaluated.

The floor space, man- and machine-hour requirements, labor and equipment costs, quality of workmanship, and equipment performance on the regular commercial line was compared with those on the experimental line and the difference in the per case costs for each system was determined.

ELECTRONIC BLOODSPOT DETECTION IN COMMERCIAL EGG GRADING

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and

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BACKGROUND OF THE STUDY

Until recently the human eye with the aid of a candling light has been the only means of determining defects of the interior of an egg as it is graded for the consumer's table. A common yet most provocative defect encountered in grading is the bloodspot. The degree of accuracy and consistency with which egg graders detect and remove eggs containing bloodspots by candling is frequently subject to debate because bloodspots continue to show up in the consumer product. Although this is understandable, the reason for the oversight seldom satisfies the consumer. Further, examination of eggs for bloodspots by the human grader is a costly part of the grading operation, especially if the effort is frequently ineffective. Adaptation of an accurate, mechanical means of detecting and removing bloodspots in a commercial egg grading operation could result in considerable economy of operation and in an improved product where it is known that the eggs are of uniformly high quality.

Recently, United States Department of Agriculture scientists developed an electronic device for detecting bloodspots in white eggs. [2] This device appeared to have the potential for substantially reducing egg marketing costs. Under certain conditions and with auxiliary equipment the device may be capable of greatly reducing labor cost while performing an improved job of bloodspot detection. This possibility is significant because total sales of eggs off farms in 1957 were about 4.6 billion dozen and marketing costs represented approximately 30 percent of consumer expenditures for eggs. Further, it is estimated that costs for grading and packing eggs account for from one-fourth to one-half of the total marketing cost.

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[1] Mr. Stoyanoff transferred from the Agricultural Marketing Service, May 1957.

[2] Brant, A. W., Norris, K. H., and Chin, Gilbert. A Spectrophotometric Method for Detecting Blood in White-Shell Eggs. Poultry Sci. 32 (2), March 1953.

U. S. Patent No. 2,700,321 for apparatus for detecting bloodspots in eggs is assigned to the U. S. Department of Agriculture. The apparatus was developed by A. W. Brant and K. H. Norris.

The objective of this study was to determine the adaptability of the electronic bloodspot detecting device to commercial egg grading and packing, and to determine the costs with and without this device. Tests were made with large white eggs: (1) With a quality range of 60 to 80 percent A quality; (2) from selected flocks with a quality range of 80 to 100 percent A quality; and (3) from selected flocks with a quality range of 80 to 100 percent A quality with conventional candling of individual eggs omitted from the system employing electronic detection.

Methods Used

1. An egg grading and packing operation without electronic bloodspot detection was analyzed; large white eggs of two different levels of quality were handled.

2. An experimental egg grading line was constructed to replicate the existing line as nearly as possible, except for the addition of a common egg supply loading facility, a flash candling device, and an electronic bloodspot detector.

3. Results of operations on the experimental line were then compared with those on the first line.

4. The operation on the experimental line was then analyzed with conventional candling of individual eggs excluded while top quality product was being handled and the results compared with findings from other methods already tested.

Research Techniques Employed

In the plant studied there was good management, consistent quality and quantity of incoming white eggs, and only a small number of variables in the type of pack and packing materials used. Graders to be studied were selected on the basis of satisfactory performance determined by plant records, and in the trial studies.

Total man-hours of labor and wait time were determined for each operation. Delays brought about by unusual conditions such as power or equipment failure, egg breakage because of malfunction of machines, or accidental mishandling not peculiar to the operation were ignored. Delays incurred by machine or operator were noted. Approximately 3,400 time readings were made to arrive at a basis for computing total labor and equipment requirements and for comparing operations. Overall costs were computed from data on labor, equipment, and methods. The relative efficiencies of each operation (table 18) were compared.

The influence of variations in egg quality and the time required for accurate grading, important factors in commercial grading, received serious consideration throughout the study. The time required to grade eggs varies with the quality of eggs handled (Appendix, fig. 29). In order to evaluate the grader's performance, it was necessary to measure not only the time required for grading but also the quality of the eggs and the accuracy with which they were graded (figs. 1, 2, and 3).

Figure 1.--Studying the grading operation to determine the time requirements.

The application of industrial engineering techniques to the analysis of the egg grading and packing operation requires a definitive terminology that the reader must keep in mind throughout the report for a complete understanding. It is important therefore that the meaning applied to the terms used in this report coincide with the definitions in the Appendix under "Definition of Terms."

Accurate evaluation of graded and ungraded product was accomplished by having a U. S. Department of Agriculture licensed grader inspect the total output of approximately 370,000 eggs. Inspectors' accuracy in judging interior egg quality was checked periodically by breaking out the eggs. The total of all qualities equaled the input quality and the difference between the inspector's and the grader's totals represented the grader's error. The effect

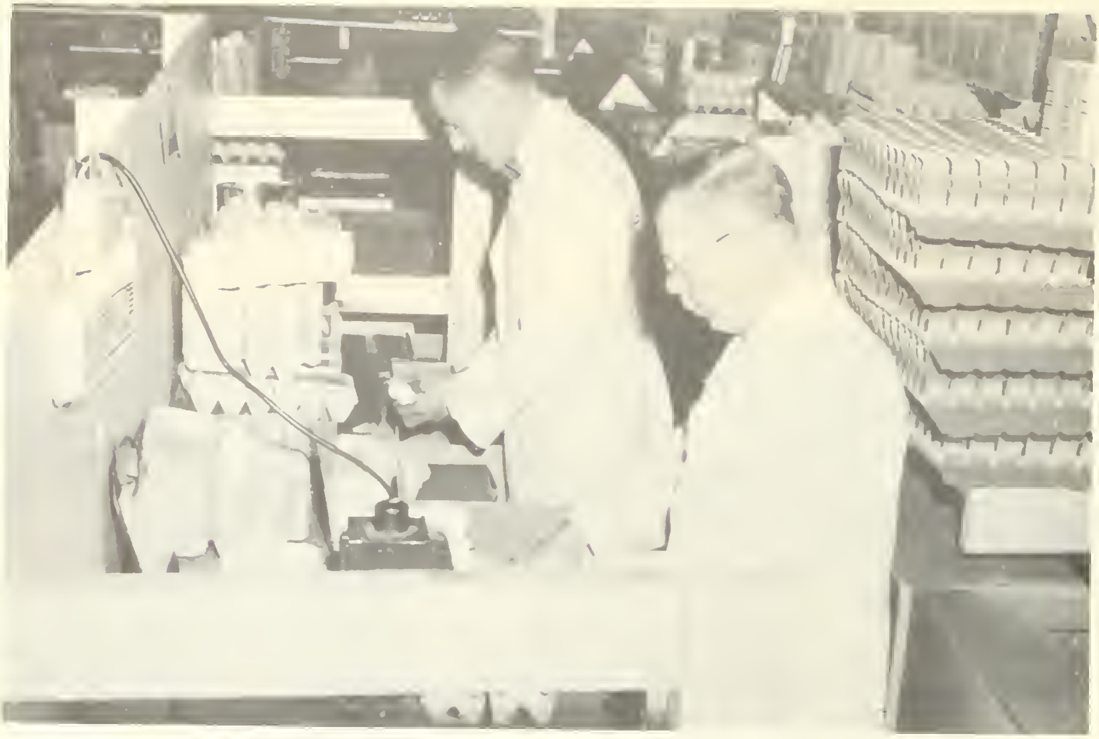

Figure 2.--Ungraded eggs are inspected to determine their quality level. The grader's workmanship is also evaluated.

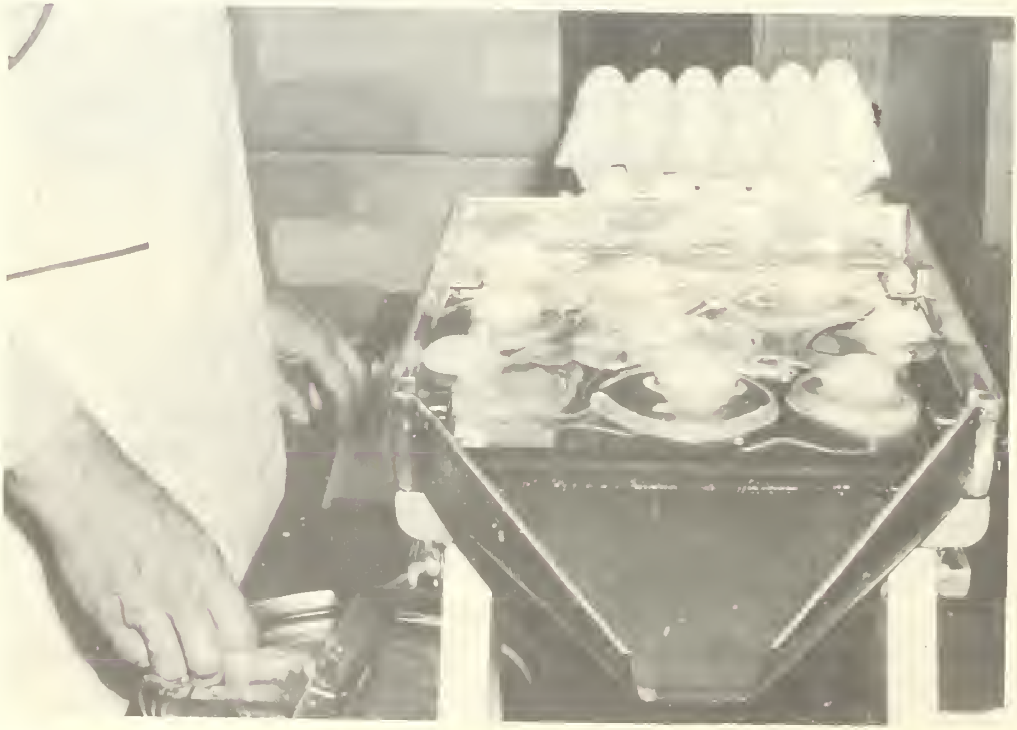

Figure 3.--Examining broken out eggs for presence of bloodspots.

of variations in quality was limited mainly to differences in the time required for making decisions as to quality or presence of bloodspots.

In order to determine the frequency with which bloodspots occurred and the accuracy with which they were removed, all the eggs in a number of the lots (11,000 eggs) were broken out and examined (fig. 3).

ANALYSIS OF A COMMERCIAL EGG GRADING AND PACKING OPERATION EMPLOYING HUMAN DETECTION OF BLOODSPOTS

Plant Selection

In selecting an egg grading and packing operation for analysis it was important to choose a plant in which a minimum of variables as to packing material, product volume, and quality prevailed. Only white eggs could be used because of detector color limitations. Eggs from selected flocks capable of producing eggs of uniformly high quality had to be available for the study. Production from select flocks had to be kept separate from production from regular flocks. Sufficient space was required in the grading and packing area to set up an experimental line that could be started and stopped intermittently while the regular packing line operated under commercial conditions. Furthermore, it was necessary that plant management be willing to put up with inconveniences connected with an experimental operation.

Layout

The egg grading and packing facilities studied were located in one room on the second floor of the building. Eggs were received and stored in a first-floor cooler and moved to the second floor by means of a belt conveyor.

Graded and packed eggs were returned to the cooler by means of a conveyor or in unit loads (fig. 4). Packing materials were brought to the second floor in unit loads (24 bundles per pallet) by elevator, stored in a room adjacent to the grading and packing area, and supplied to graders as necessary.

The commercial grading line hereafter referred to as system "A" consisted of 9 grading booths and a reject packing booth, work stations 2 through 11 occupying a space next to the wall on the long side of the room (fig. 5). It supplied each grader with flat loads of eggs by means of individual crossfeed conveyors from work stations 1 (figs. 5 and 6). A 5-foot rotary carton packing table was located at the end of the line at station 12 (figs. 5 and 7) to receive cartoned eggs for packing. The system considered as one unit occupied an oblong space approximately 84 feet long and 20 feet wide.

The area in the center of the room was designated for temporary storage of packing materials and graded eggs and for carton makeup operations (figs. 5 and 8).

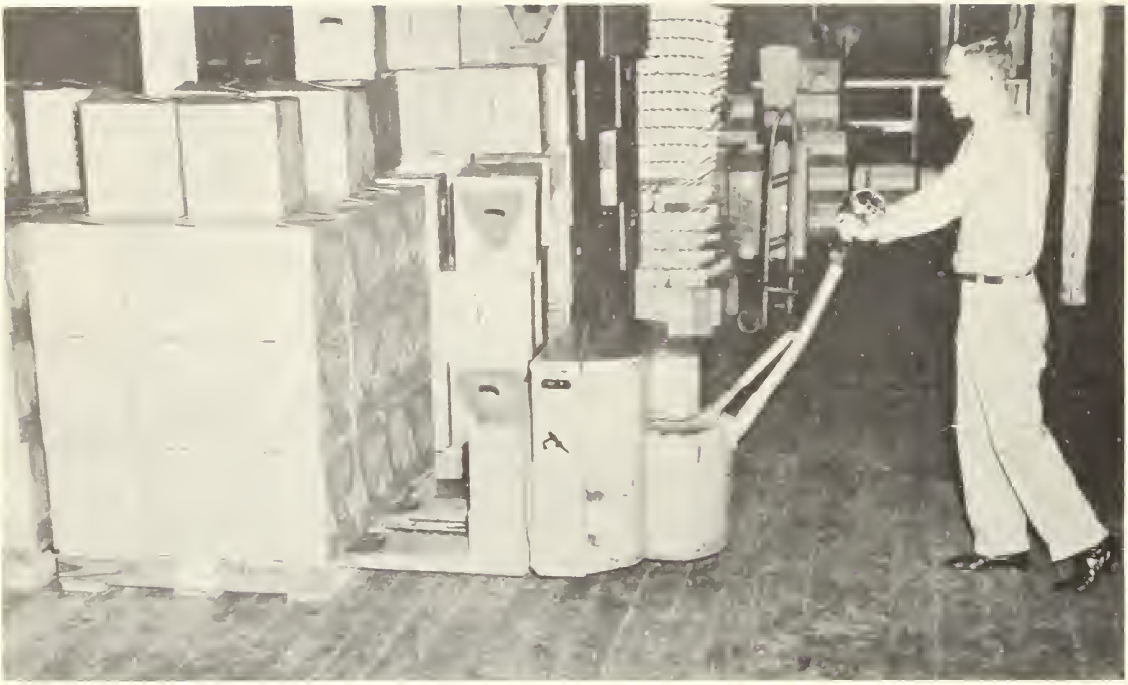

Figure 4.--Preparing to move unit load of eggs.

Flow of Product and Materials

Flow of Eggs

Eggs arriving in the grading and packing area from the first floor came to a stop on a short section of roller conveyor at the receiving end of the grading line (fig. 9) and were then diverted to the skate conveyor in front of the grading line (fig. 10).

The worker supplying the grading line moved eggs from the conveyor to workbenches by crossfeed belts, at each of the work stations designated as No. 1 (fig. 5). Each case was emptied, filler-flat at a time, to the crossfeed conveyors that moved the eggs under the front partition to points immediately in front of and within convenient reach of the graders (figs. 11 and 12).

As eggs were graded and packaged in cartons, a belt conveyor (fig. 13) extending the entire length of the grading line carried full cartons of graded eggs through either of two automatic closing and sealing units connected with the packing table (fig. 14). As cases were packed with cartons, they were sent to the cooler on a powered belt conveyor (fig. 5).

GRADING ROOM LAYOUT WITH COMMERCIAL LINE SYSTEM "A" AND EXPERIMENTAL LINE SYSTEM "B".

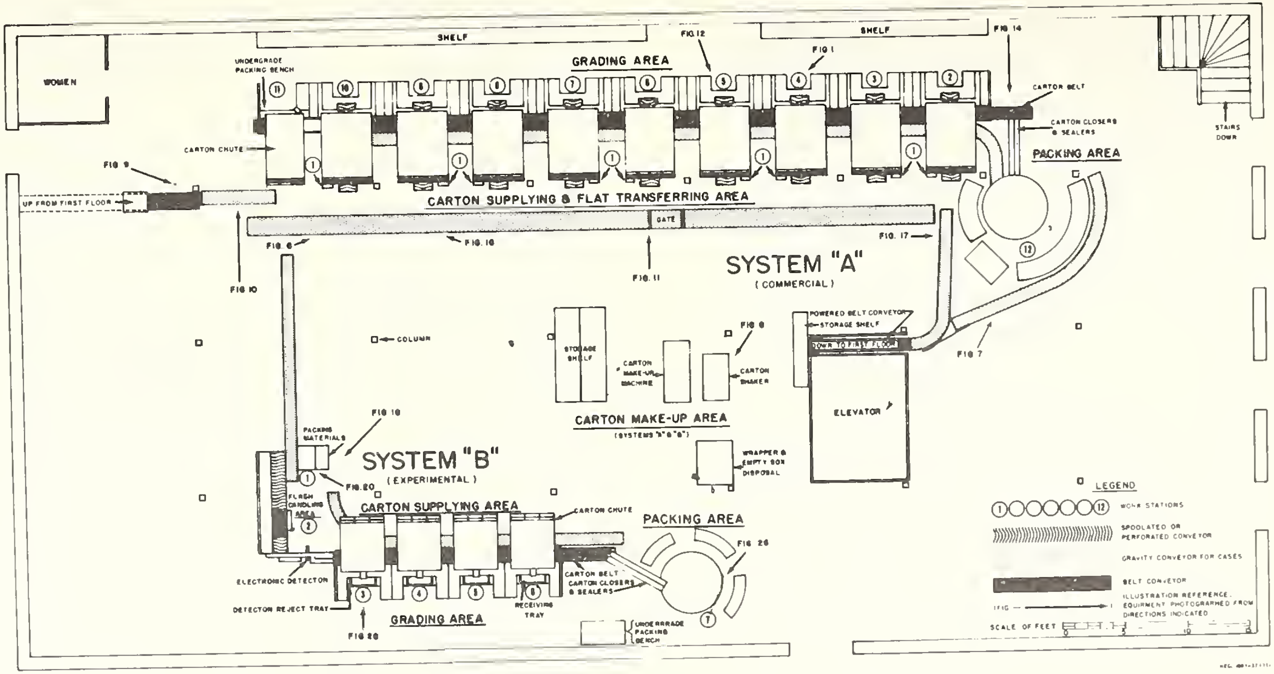

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Figure 5.

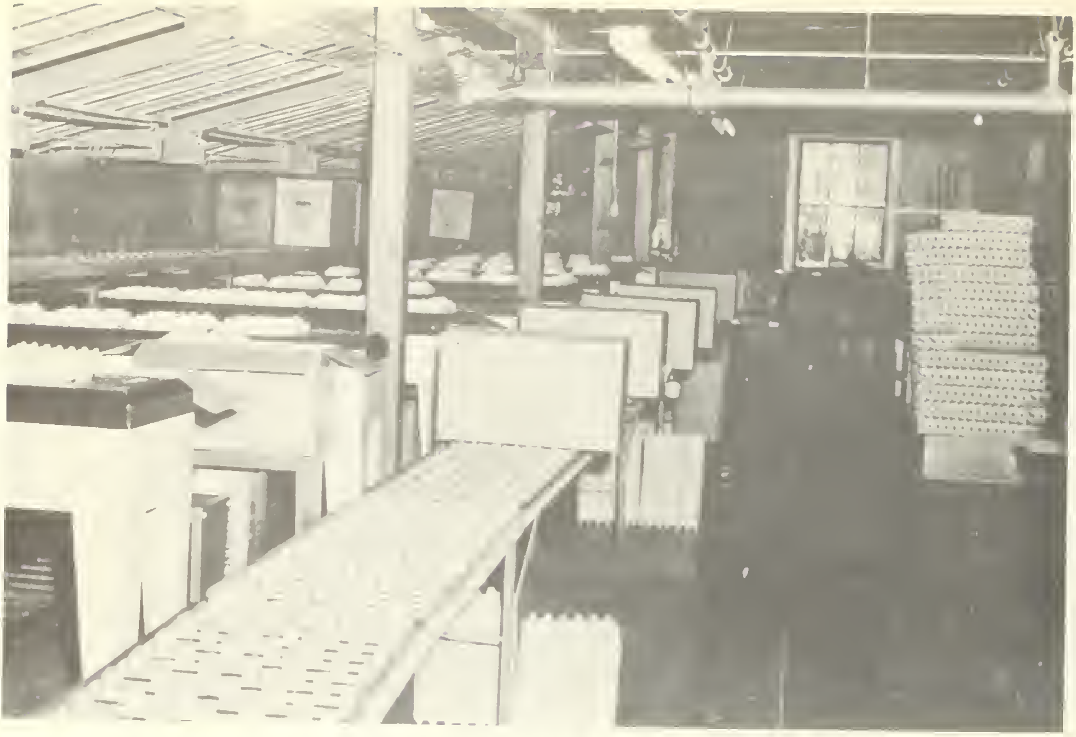

Figure 6.--Grading line with loaded conveyors for each grading station; system A (commercial).

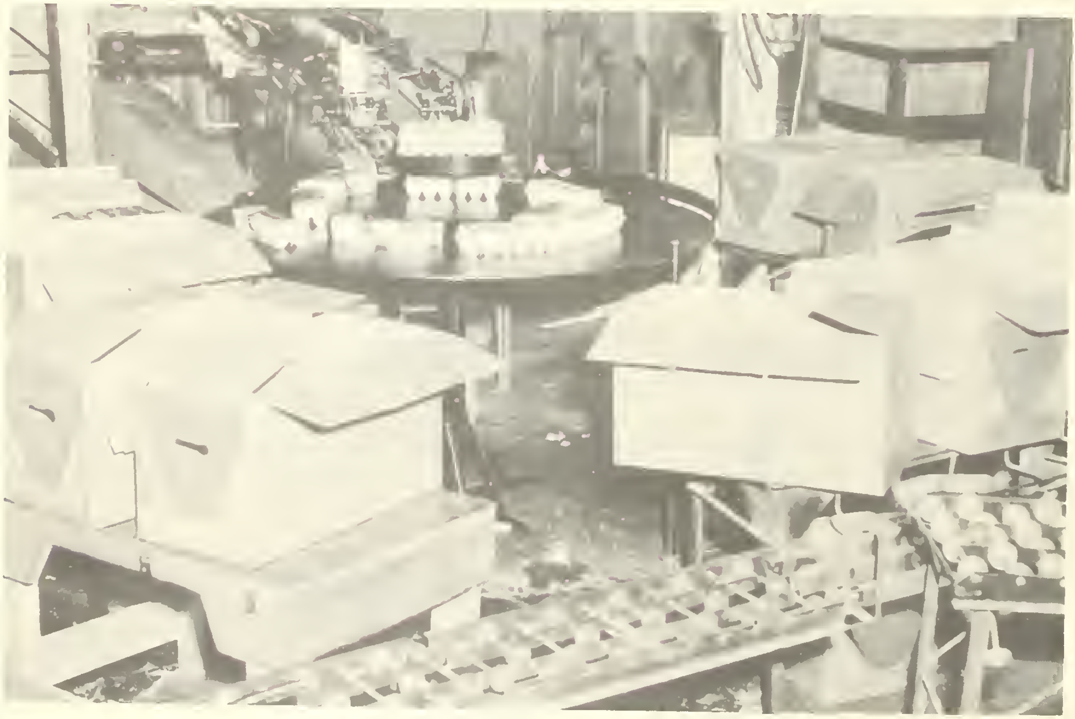

Figure 7.--Rotary packing table at end of grading line; system A.

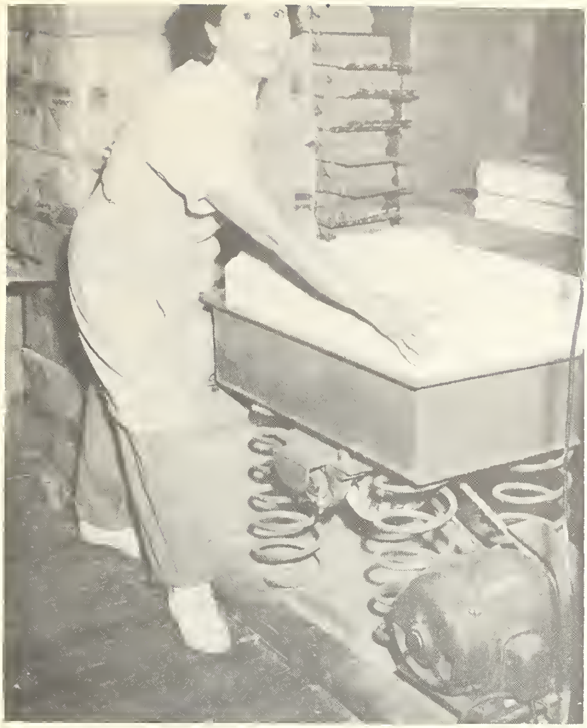

Figure 8.--Preparing molded pulp cartons for use.

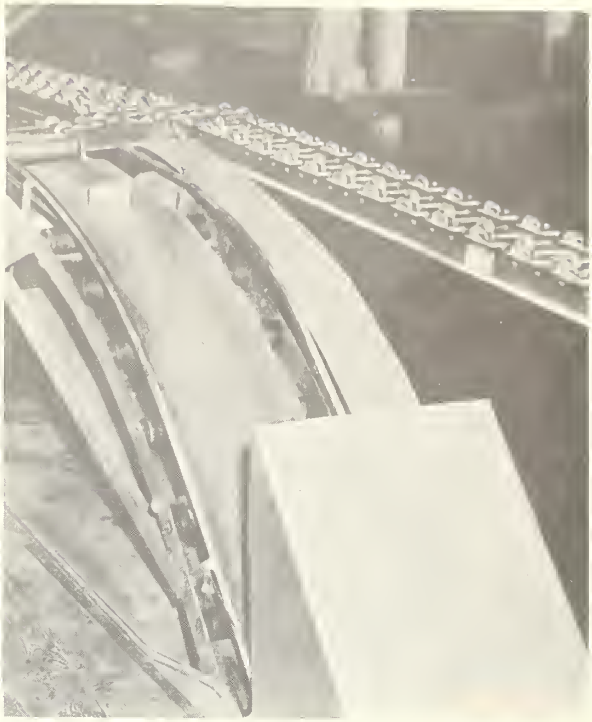

Figure 9.--Belt conveyor moves incoming eggs to second floor.

Accumulations of undergrade and reject eggs at stations 2 through 10 were collected at intervals and packed in cases at the undergrade and reject packing bench, station 11 (fig. 5). Unit loads of undergrades were temporarily stored near station 11 and transported to the cooler as necessary.

Flow of Packing Materials

Cartons were obtained from the storage room either in single bundles or in unit loads of 24 bundles per pallet and temporarily stored next to the carton makeup machine (fig. 5). After cartons were formed or otherwise prepared for use, they were stacked near the carton shaker or makeup machine ready for distribution to the grading benches. A worker emptied the egg cases and transferred the flats. The cases then were either moved by gravity conveyor directly to the packing table, or they were collapsed and stacked on a skid for transport to the shipping department. Filler-flats were stacked alongside each grader after the eggs had been removed for grading. Accumulations of approximately 35 filler-flats were pushed across the grading bench to the worker supplying eggs to the line. Each stack was then placed under the bench for removal by another worker at a later time.

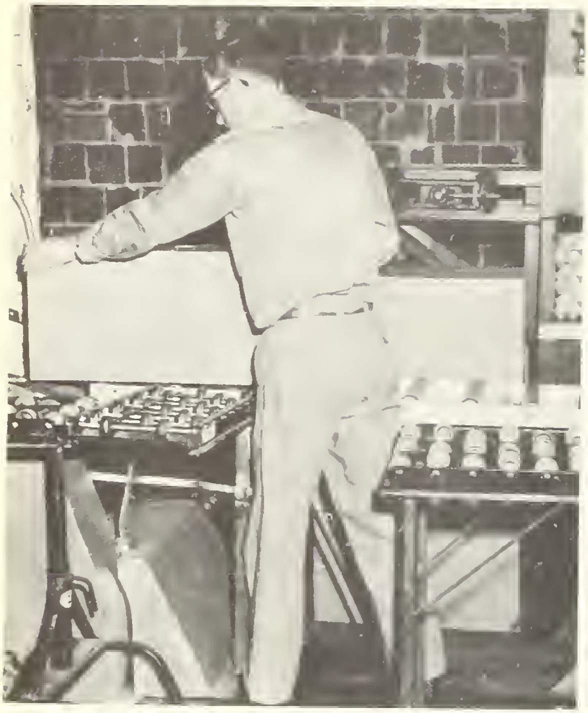

Figure 10.--Incoming eggs are diverted to skate conveyor in front of grading line.

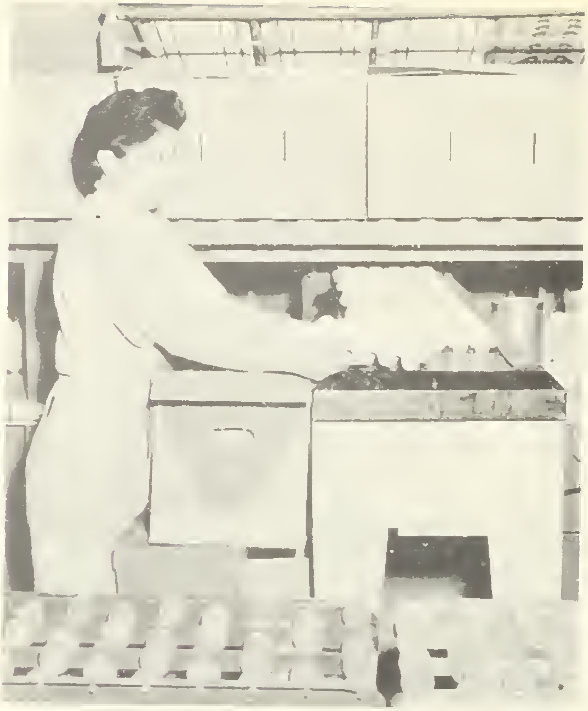

Figure 11.--Loading eggs on crossfeed conveyor to one of the grading booths.

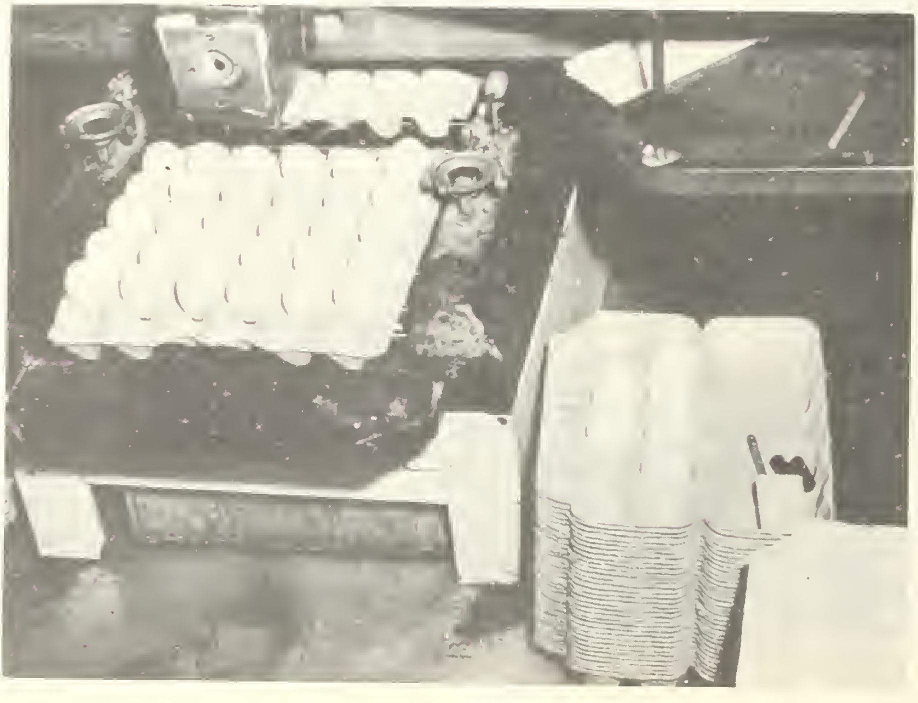

Figure 12.--Eggs on crossfeed conveyor are ready to be candled.

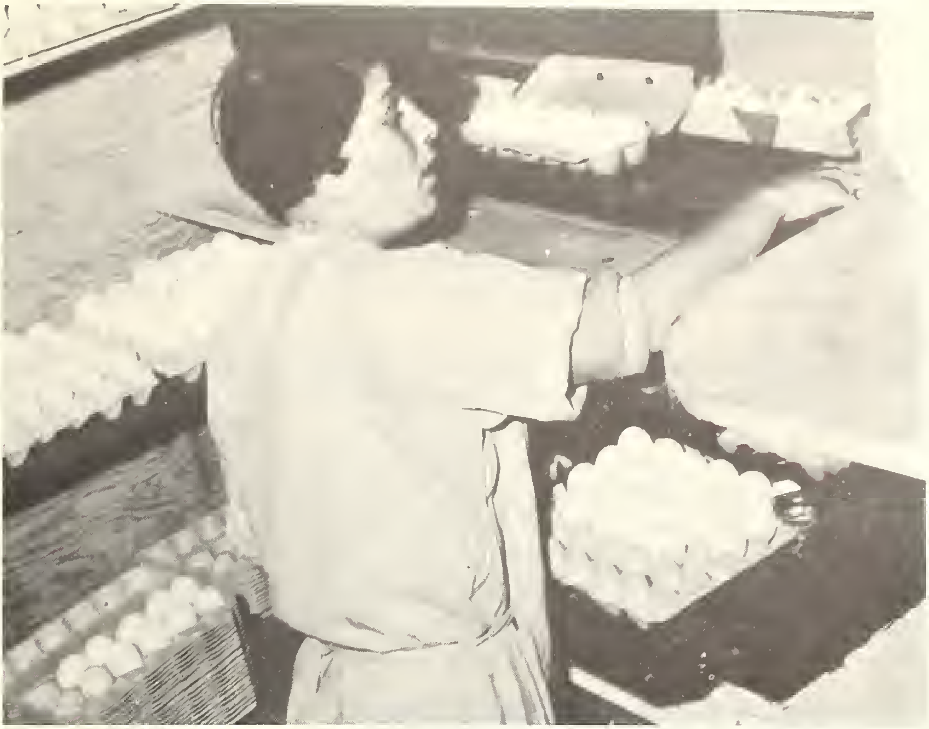

Figure 13.--Cartoned eggs are placed on conveyor belt.

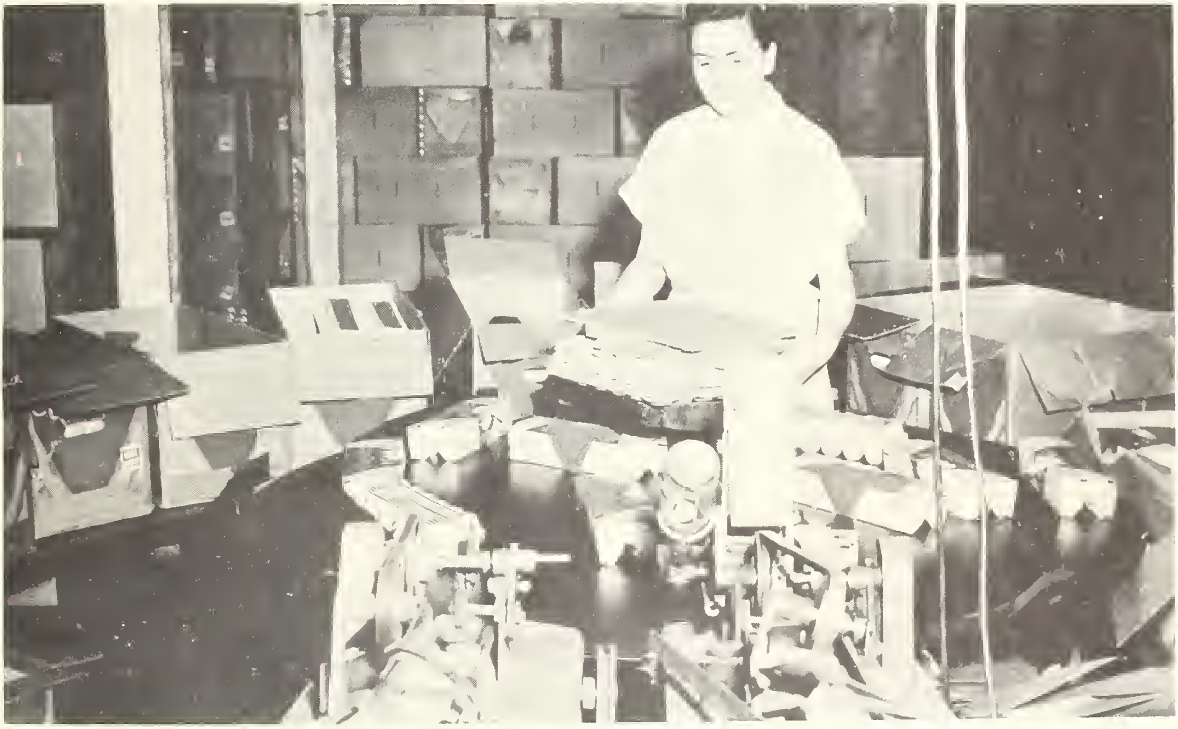

Figure 14.--Two closing units feed cartoned eggs to packing table.

Description and Analysis of Operations

Full Case Supplying

Normally, the operation of supplying the system with eggs would not be considered beyond the point where a crew member begins handling the product for the processing operation, because handling beyond this point is considered materials handling. However, due to the necessity of operating both systems simultaneously in the same room, slight differences in layouts were required, resulting in variations in time requirements for the operations.

The operation began with diverting full cases received from the first floor. They were then transferred to the conveyor serving the grading line. About 400 cases were handled in this manner daily. Generally, enough cases were received to load the conveyor in front of the grading line. Since the conveyor was level, it was necessary to push each case into position to make room for the next. Full cases were diverted at a rate of about 10 cases per minute. Thus a worker needed only about 5 minutes to load the conveyor to its 50-case capacity. This is determined on the basis of requiring 0.16 man-hour of labor to divert 100 full cases of eggs to the conveyor.

Flat Transferring

Incoming cases were moved from the conveyor in front of the grading line to a bench next to each station crossfeed conveyor. Cases were emptied by transferring the contents, one filler-flat (30 eggs each) at a time, until the conveyor was loaded. The capacity of the portion of the crossfeed conveyor accessible to the worker was about 5 filler-flats; therefore, flat loads were transferred intermittently as the egg supply was used by each grader.

When a case was emptied, it was placed on an overhead conveyor (fig. 11) leading to the carton packing table. Empty filler-flats were accumulated by the grader in stacks of about 35 for temporary storage under the conveyor and were picked up by another worker at intervals. The operator transferring eggs to the crossfeed conveyors used 34.4 percent of her time walking between transfer stations. The main segment of the operation, egg transferring, required 35.5 percent of her time, and 30.1 percent was divided between handling cases and filler-flats (table 1). One worker transferred 54 cases per hour in serving 9 graders. If additional loading space had been provided on each conveyor, the productivity could have been increased because the frequency of serving each station would have been reduced.

Grading and Packaging

Grading and packaging (see definition of terms in Appendix) consisted of several related operations: (1) Grading eggs, (2) obtaining and placing empty cartons on shelf, (3) obtaining and positioning empty filler-flats for rejects, (4) stacking empty filler-flats for disposal, and (5) pushing full

Table 1.--Labor required by one worker to transfer 100 cases of eggs onto a crossfeed conveyor; system "A" (commercial) 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Handle full cases	0.23	12.4
Remove top flats	.06	3.2
Transfer flat-loads of eggs	.66	35.5
Handle empty cases	.17	9.1
Dispose empty flats 2/	.10	5.4
Walk empty	.64	34.4
Total labor	1.86	100.0

1/ Removing 12 filler-flat loads of 30 eggs each per case.
2/ 200 top filler-flats and 1,100 filler-flats from graders.

cartons onto belt. Grading eggs required approximately 90 percent of the grader's productive time and the remainder of the time was divided among other related elements of the operation. Table 2 shows that the production rate per grader on system A, when grading and packing 60 to 80 percent A quality, was approximately 4 cases per hour or 32 cases per 8-hour day. When grading and packing 80 to 100 percent A quality, production was approximately 5 cases per hour or 40 cases per 8-hour day. When the materials-handling labor factor was not included in the operation approximately 4.6 cases were graded per hour at the 60 to 80 percent A quality level, and 5.9 cases per hour at the 80 to 100 percent A quality level. Cartons were obtained from overhead racks (fig. 15) filled and placed on the conveyor belt (fig. 13). Empty filler-flats were stacked on the grading bench beside the grader for disposal, at intervals to the worker who loads the egg supply conveyors, or they were placed in position on the grading bench for undergrades or rejects.

Undergrade and Reject Packing

Undergrades and rejects were packed intermittently. One worker, usually one of the graders, walked the length of the grading line at intervals, collecting flats of undergrades or rejects requiring packing. The pickup operation was timed so as to average approximately 6 filler-flats per trip. Flat loads were packed into 30-dozen cases. They were then moved from the

Table 2.--Labor required by 1 worker to grade and package 100 cases of eggs of specified qualities; system A 1/

Time item	Labor required when--		Percentage of total labor when--	
	60 to 80 percent of eggs are A quality	80 to 100 percent of eggs are A quality	60 to 80 percent of eggs are A quality	80 to 100 percent of eggs are A quality
	Man-hours	Man-hours	Percent	Percent
Grade eggs	21.80	16.98	90.3	87.8
Push full cartons onto belt and place empty cartons onto shelf.	2/ 2.01	2/ 2.01	8.3	10.4
Position empty filler-flats	.07	.07	.3	.4
Stack empty filler-flats .	.27	.27	1.1	1.4
Total labor. .	24.15	19.33	100.0	100.0

1/ 93 percent in molded pulp cartons and 7 percent in filler flats.
2/ Requirement for chipboard cartons was 1.28 man-hours.

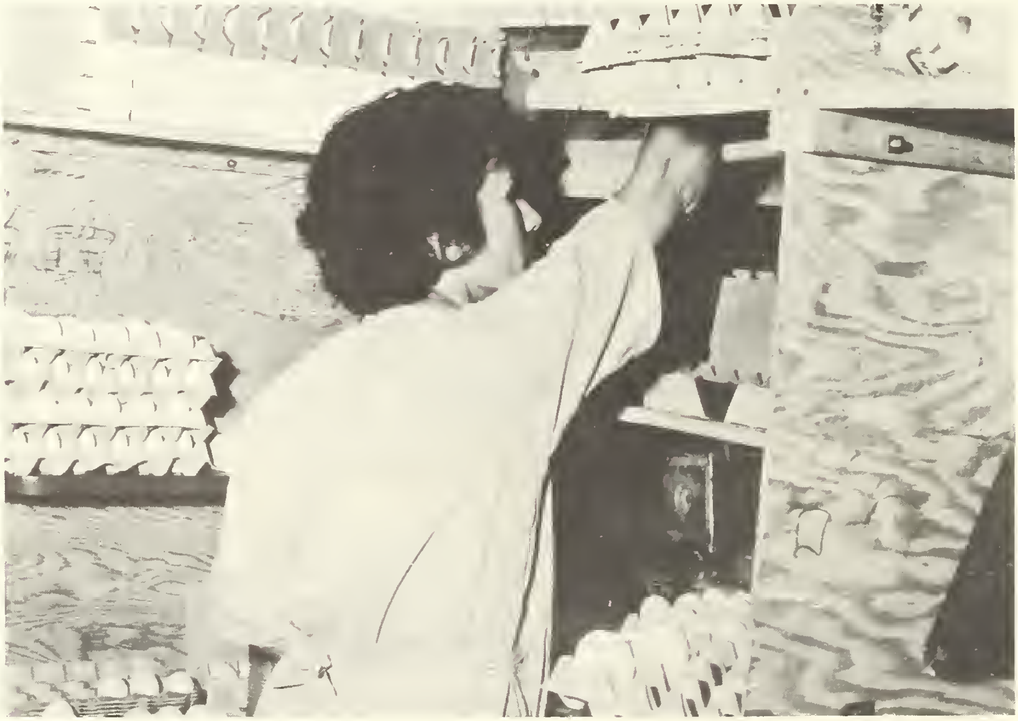

Figure 15.--Obtaining carton from overhead rack.

packing bench to a loading area in the middle of the grading floor. In packing 100 cases of rejects 6.92 man-hours (table 3) were required; however, since rejects occurred at a rate of 7 cases out of every 100, only 0.48 man-hour was required to handle reject packing per 100 cases graded. Thus the total labor involved in this operation was of minor significance.

Since the percentage of undergrades packed in fillers and flats differed only slightly between the 2 quality groups studied, the same ratio--93 percent carton pack and 7 percent bulk pack--was used for both qualities.

Table 3.--Labor required by 1 worker to collect and pack 100 cases of undergrade and reject eggs; system A 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Handle empty cases	0.18	2.6
Collect and pack flat-loads of eggs. . .	6.56	94.8
Handle full cases.	.18	2.6
Total labor	6.92	100.0

1/ Average production rate of undergrades and rejects was 7 cases per 100 cases of ungraded input (0.48 man-hour).

Carton Making and Supplying

Bundles of molded pump cartons were unwrapped at the temporary storage point in the carton makeup area and placed into a vibrating device (fig. 8) that served to loosen the cartons one from another. Approximately 125 cartons were distributed at a time to each grading station as needed. Backlog supplies were placed on shelves next to the vibrator.

Chipboard cartons held in temporary storage in the carton supply area were removed from fiber containers about 50 at a time and fed into the carton setup machine that operated at a rate of 45 cartons per minute. Cartons were removed from the machine and distributed as needed to each grading station, 20 to 30 cartons at a time. Backlog supplies of made-up cartons were stacked on shelves next to the carton makeup machine.

Each grading station was equipped with a battery of counterbalanced carton chutes that could be rotated into position for loading (fig. 16). When released, the chutes returned to position in front of the grader. The device made use of the principle of overhead carton supply in a room in which

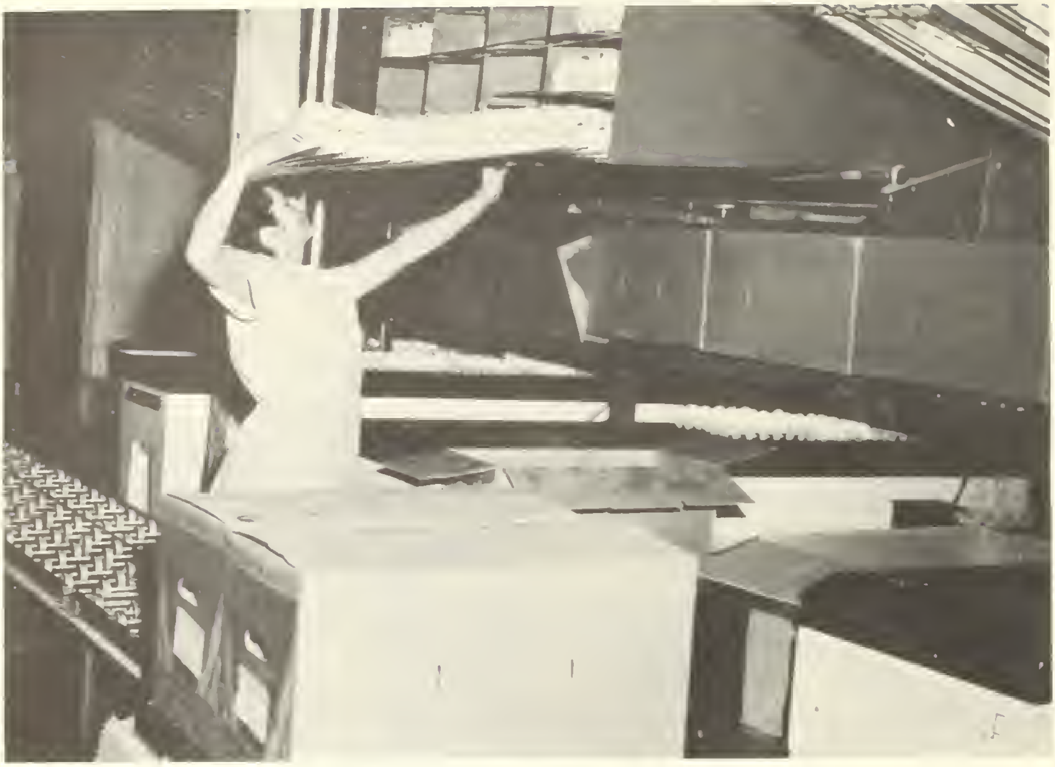

Figure 16.--Loading carton chute with chipboard cartons.

space for a carton mezzanine was not available. However, drawbacks to the equipment were the long reach required of the carton supplier (fig. 16) and occasional worker interference with the transferring operation.

The labor requirements for carton making and supplying were approximately 2 man-hours for preparing and distributing cartons for 100 cases of eggs when chipboard cartons were used, and approximately one-third of an hour when molded pulp cartons were used (tables 4 and 22, Appendix). This considerable difference was largely due to makeup time and extra walk time required for chipboard cartons. In the grading and packing crew requirement comparisons, as well as in the comparison of the systems, only the data for molded pulp cartons were used because of the labor savings they showed over chipboard cartons in the makeup and supply operation. Advantages or disadvantages of the two carton types in other operations were not studied.

Carton Packing

Full cartons arriving on the carton packing table were placed into one of the empty cases on benches arranged in a semicircle around the table. Packing the various grades of cartoned eggs involved a 90° turn for the packer when moving the cartons from the table into the cases (fig. 17). When a case

Table 4.--Labor required by 1 worker to prepare and distribute the equivalent of 100 cases of molded pulp cartons; system A 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Handle bundles of cartons	0.15	40.6
Load carton chutes	.13	35.1
Walk empty	.09	24.3
Total labor	0.37	100.0

1/ Production rate of cartoned eggs averaged 2,800 dozen per 100 cases of ungraded input (0.35 man-hour). Labor required for chipboard cartons is shown in table 22 (Appendix).

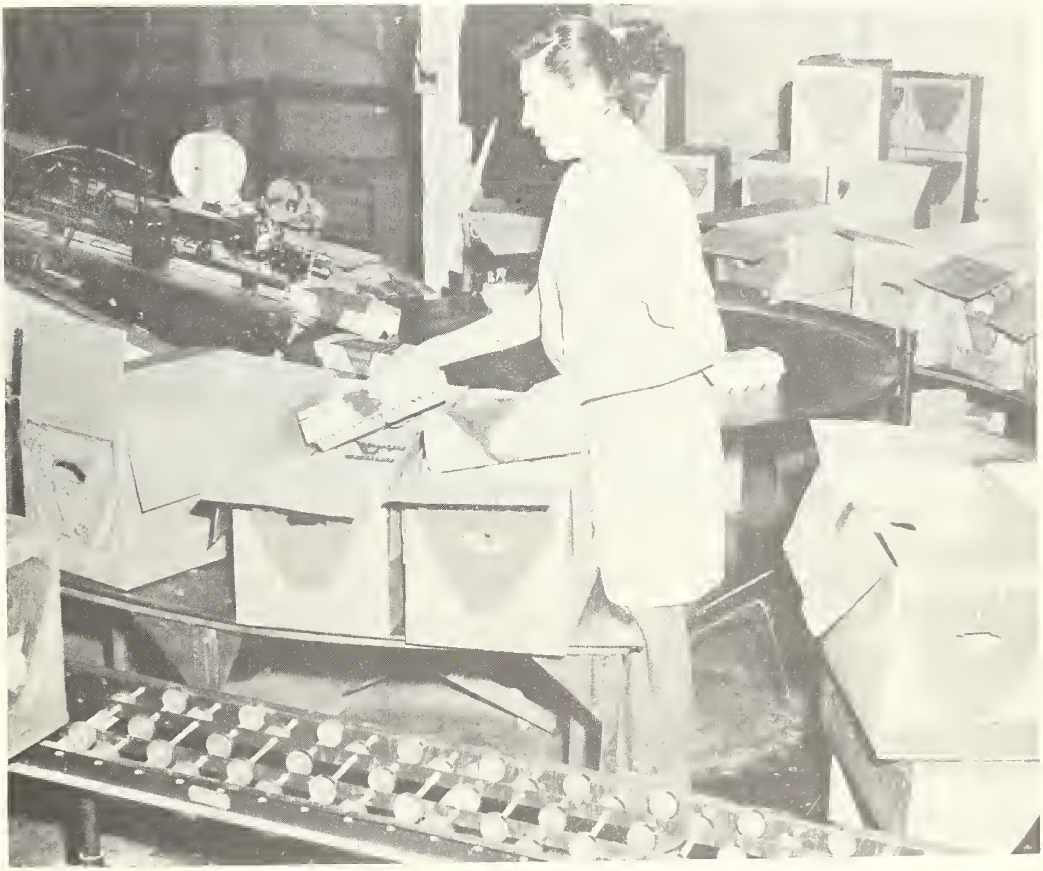

Figure 17.--Packing station, system A.

was filled, the top flats were interlocked and the case was placed on a conveyor leading to the cooler (fig. 18). Analysis of the carton packing operation indicated that about 74 percent of the packer's time is devoted to packing cartons into cases. Packing the equivalent of 100 30-dozen fiber cases required 2.03 man-hours (table 5).

Empty cases for packing were obtained from the conveyor that connected loading stations with the packing station.

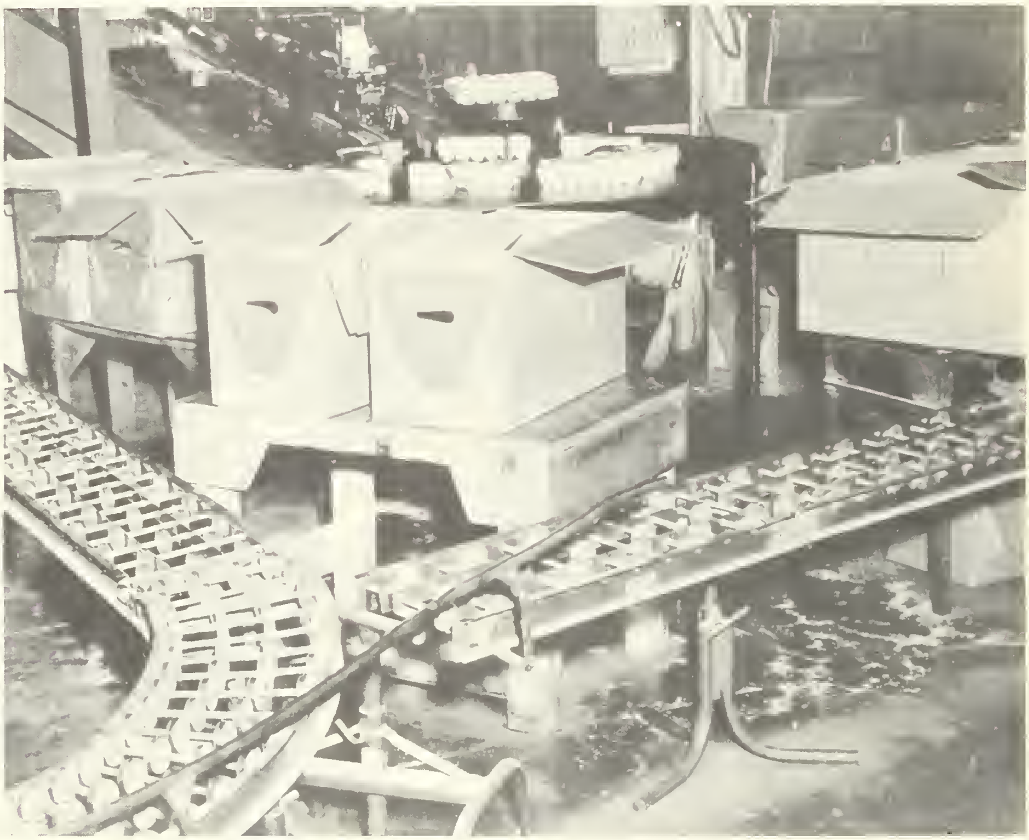

Figure 18.--Conveyors around packing benches lead to cooler.

Cost Analysis of System A (Commercial)

In order to provide a practical analysis of egg grading and packing in a commercial operation, it was necessary to consider labor requirements and labor and equipment costs at the two levels of product quality that predominated in the plant receipts during the time of the study. The need for this approach can readily be seen by noting that the grading and packaging labor represents 79 percent of the total labor (table 7) and increased 25 percent when product in the lower quality bracket was graded and packaged (table 6).

Table 5.--Labor required by 1 worker to pack 100 cases of cartoned eggs into 30-dozen fiber cases; system A [1]

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Handle empty cases	0.24	11.8
Pack cartons	1.50	73.9
Handle full cases	.29	14.3
Total labor	2.03	100.0

[1] Average production rate of cartoned eggs was 93 cases per 100 cases of ungraded input (1.89 man-hours).

The equipment cost figures used were based on data obtained from company records (Appendix page 48, table 19). The hourly wage rate used for all workers was determined at $1.68 per hour (Appendix page 48).

Sixty to Eighty Percent A Quality

The labor in grading and packaging constitutes 79.2 percent of the labor required for the entire grading and packing operation (table 6). The average output for each of 9 graders was 4.2 cases per hour. Unproductive labor represented 5.3 percent of the total time.

In the full case supplying, carton supplying, and undergrade and reject packing operations, amounting to 0.99 man-hour, no assessment of unproductive time was made for the reason that the jobs were not tied to the overall operation and permitted performance of related or unrelated duties required by management in the packing and grading area.

In a period of 2.68 elapsed hours a 13-man crew required 30.50 man-hours and 2.68 machine-hours to grade and package 100 cases of large eggs of 60 to 80 percent A quality in filler-flats and molded pulp cartons, and to pack the cartons into 30-dozen fiber cases by system A. Labor and equipment costs are summarized in table 18, page 44.

The crew handled this operation as follows: 9 workers graded and packaged eggs, 1 worker collected and packed undergrades and rejects, 1 worker supplied cartons to graders, 1 worker supplied eggs to graders, and 1 worker packed cartons into cases.

Table 6.--Labor required for a 13-man crew to grade and package 100 cases of large eggs, 60 to 80 percent A quality, into filler-flats and molded pulp cartons and pack into 30-dozen fiber cases, system A 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Productive labor:		
Full case supplying	2/ 0.16	0.5
Flat transferring	1.86	6.1
Grading and packaging	24.15	79.2
Undergrade and reject packing	3/ .48	1.6
Carton supplying	4/ .35	1.1
Carton packing	1.89	6.2
Total productive labor	28.89	94.7
Unproductive labor:		
Worker transferring flats waits on graders	.82	2.7
Carton packer waits on graders	.79	2.6
Total unproductive labor	1.61	5.3
Total labor	30.50	100.0
Elapsed hours	2.68	

1/ Crew organization: 1 worker transfers flats, 9 workers grade and package eggs, 1 worker collects and packs undergrade and reject eggs, 1 worker supplies cartons, 1 worker packs cartons.

2/ Full case supplying is not a function of the system; therefore, this worker is not included as a crew member. However, since the labor is required to enable the system to operate, it is included as part of the total labor with no idle time involved.

3/ Operation performed by a worker whose main duty is other than collecting and packing undergrade and reject eggs; idle time not involved.

4/ Carton supplier performed unrelated duties not evaluated in this study; idle time not involved. Requirement for chipboard cartons was 2.11 man-hours.

Labor costs for the operation computed at $1.68 (Appendix, page 48) per hour were $51.24; equipment costs (Appendix, page 48 and table 19) $5.79; total $57.03. Labor for grading and packaging alone was $40.57. The total cost per case is about 57¢ and the labor cost is approximately 51¢ of which approximately 40½¢ per case is required for grading and packaging, and 36½¢ is for grading eggs (table 2--grade eggs 21.8 hrs. x $1.68 per hour ÷ 100 cases = $0.366 per case).

Eighty to One Hundred Percent A Quality

Grading and packaging constitutes 78.5 percent of the overall grading and packing operation (table 7). The average output for each of the 9 graders is 5.2 cases per hour. The unproductive time in the crew when working this quality represents 2.2 percent. At this quality level the production rate of the main operation, grading and packaging, was increased and the unproductive time was decreased, thereby increasing the overall efficiency.

Table 7.--Labor required for a 13-man crew to grade and package 100 cases of large eggs, 80 to 100 percent A quality into filler-flats, and molded pulp cartons and pack into 30-dozen fiber cases, system A 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Productive labor:		
Full case supplying	2/ 0.16	0.6
Flat transferring	1.86	7.6
Grading and packaging	19.33	78.5
Undergrade and reject packing	3/ .48	2.0
Carton supplying	4/ .35	1.4
Carton packing	1.89	7.7
Total productive labor	24.07	97.8
Unproductive labor:		
Worker transferring flats waits on graders	.29	1.2
Carton packer waits on graders	.26	1.0
Total unproductive labor	.55	2.2
Total labor	24.62	100.0
Elapsed hours	2.15	

1/ Crew organization: 1 worker transfers flats, 9 workers grade and package eggs, 1 worker collects and packs undergrade and reject eggs, 1 worker supplies cartons 1 worker packs cartons.

2/ Full case supplying is not a function of the system; therefore, this worker is not included as a crew member. However, since the labor is required to enable the system to operate, it is included as part of the total labor with no idle time involved.

3/ Operation performed by a worker whose main duty is other than collecting and packing undergrade and reject eggs; idle time not involved.

4/ Carton supplier performed unrelated duties not evaluated in this study; idle time not involved. Requirement for chipboard cartons was 2.11 man-hours.

In 2.15 hours elapsed time a 13-man crew required 24.62 man-hours and 2.15 machine-hours to grade and package 100 cases of large, 80 to 100 percent A quality eggs in filler-flats and molded pulp cartons and pack the cartons into 30-dozen fiber cases by system A. Labor and equipment costs are summarized in table 18, page 44.

The crew handled this operation as follows: 9 workers graded and packaged eggs, 1 worker collected and packed undergrades and rejects, 1 worker supplied cartons to graders, 1 worker supplied eggs in flats to graders and 1 worker packed cartons into cases.

Labor costs for the operation, computed at $1.68 per hour (Appendix, page 48) were $41.36; equipment costs computed at $2.16 per hour (Appendix, page 48, table 19) were $4.64; total $46. Labor for grading and packaging alone was $32.47.

The total cost per case then is 46¢ of which approximately 41¢ is labor cost. In the labor cost figure, approximately 32½¢ is required for grading and packaging labor, 28½¢ of which is for grading (table 2--grade eggs 16.98 hours x $1.68 per hour ÷ 100 cases = $0.285 per case). If this level of product quality is not available and only 60 to 80 percent A quality is handled, consideration can be given to increasing the grading and packaging crew from 9 to 10 or 11 workers by adding grading equipment at a small additional cost. The elapsed time for the entire operation would be reduced and the overall efficiency increased. However, with this increase in crew size the time that the carton supplier and undergrade and reject packer will have available to perform other duties assigned by management, will have to be reduced.

INTEGRATION OF ELECTRONIC BLOODSPOT DETECTION INTO A COMMERCIAL EGG GRADING AND PACKING LINE

Principle of Operation

The main considerations in developing an egg grading line that would test electronic bloodspot detection under commercial conditions required effecting the following: (1) Multiple egg transfer from case to "spoolated" conveyor constructed to accommodate 6 rows of eggs (see Definition of Terms in Appendix); (2) removal of defective shells and opaque eggs as they slowly rotate on a conveyor first illuminated from above and then from below; (3) conversion of 6 rows of eggs into single file; (4) transferring eggs from a single file conveyor to and in synchronization with the electronic detector pickup device that stops each egg before the detector scanning device for an instant; (5) moving eggs containing bloodspots which are diverted by the detector to a reject packing station; (6) moving acceptable eggs away from the detector and diverting them as needed into 4 grading and packing stations; and (7) provide grading, packaging, and carton packing facilities similar to the grading line of system A.

Description

The commercial bloodspot detector effectively scanned up to 20 cases (7,200 eggs) per hour. 3/ The equipment supplying eggs to the detector was timed to match the detector volume at all levels of production. A spoolated conveyor capable of carrying eggs 6 abreast in a forward direction with intermittent hesitation as eggs are rotated was used (fig. 19). Eggs were loaded on the conveyor with a multiple egg lifting device (fig. 20).

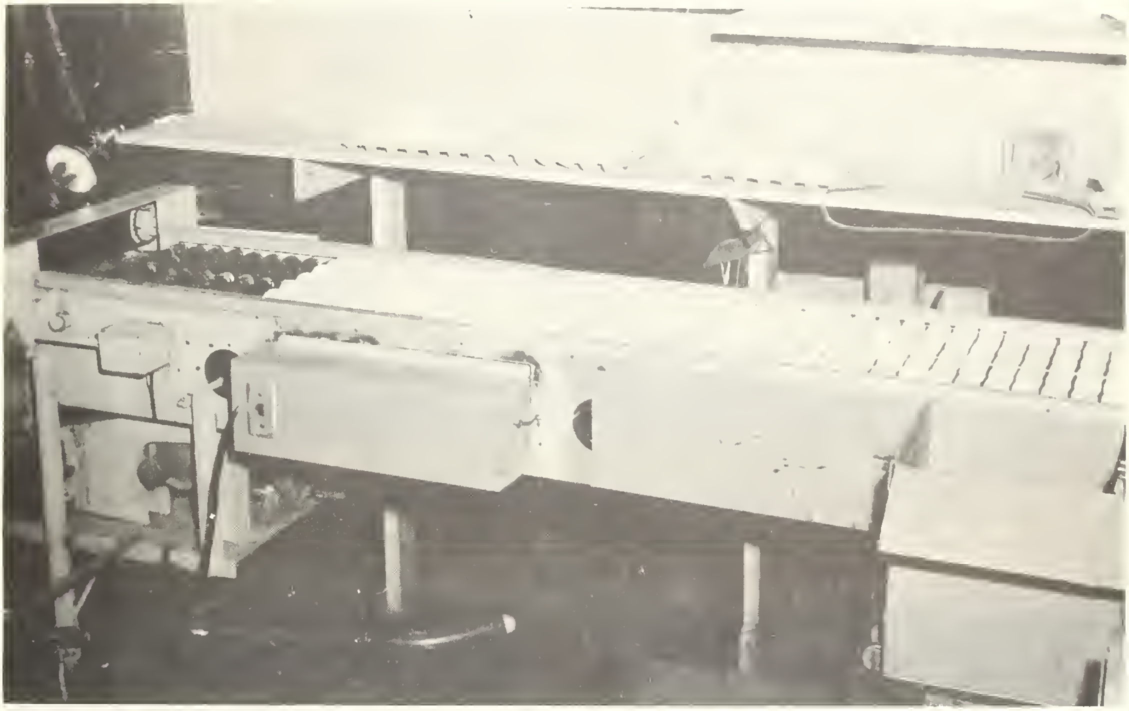

Figure 19.--Eggs 6 abreast on spoolated infeed conveyor.

The loading area was illuminated by overhead lighting for the purpose of detecting and removing smashed, checked and dirty eggs at the time of loading. Toward the discharge end of the conveyor an underlit area provided interior egg illumination for the purpose of detecting and removing defective eggs such as blind checks and opaque eggs (figs. 21 and 27). Thus, a means of removing eggs that might smash in the line or eggs that could be missed by the detector was provided. These operations at the infeed conveyor, known as "flash candling," became a part of the grading operation. As the eggs, in 6 abreast formation, reached the end of the conveyor they were automatically pushed onto a 4-inch belt. The belt was equipped with recesses for single eggs and moved at right angles to the conveyor (fig. 22). The transfer was

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3/ During some periods in the study, operating speeds up to 22 cases per hour were noted, but the average operating speed was 17.7 cases per hour

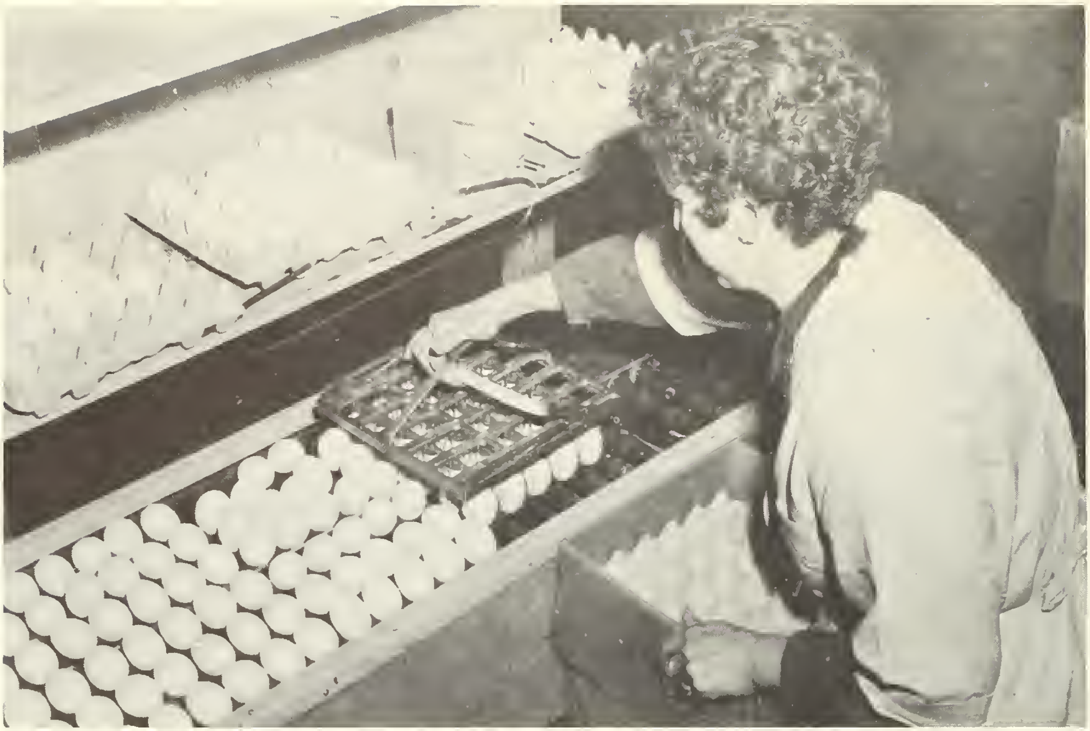


Figure 20.--Transferring 30 eggs from case to conveyor.

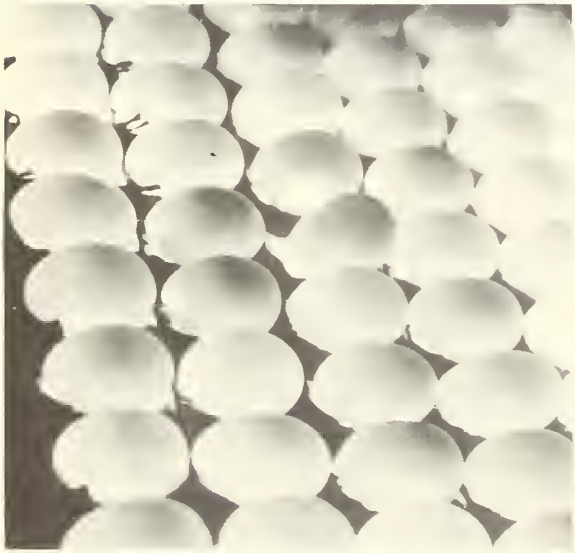


Figure 21.--Underlit portion of conveyor for detection of checked and opaque eggs.

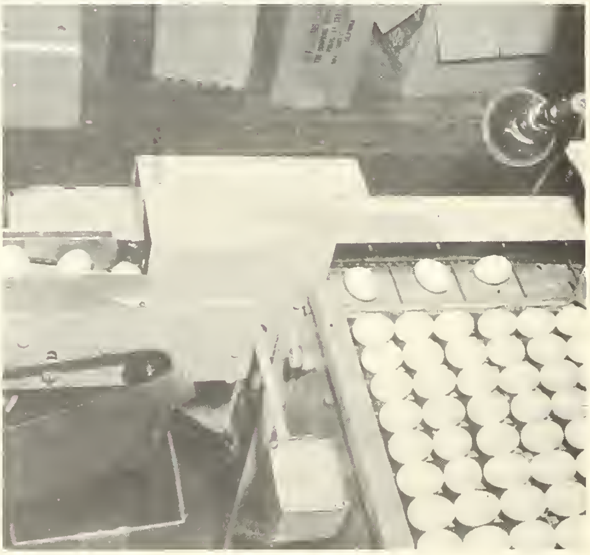


Figure 22.--Eggs are translated from 6-abreast to single file (right) and are then elevated to detector (left).

effected by 6 pusher bars which gently moved the eggs from the last row of the spoolated conveyor to the single file belt in synchronization with the movement of a series of cross bars (fig. 22, right; cross bars are dark lines behind each egg) moving above and slightly faster than the single file belt. Thus, the rolling motion of the eggs was stopped and they were positioned for transfer to the elevator that delivered them to the detector unit. The elevator was an inclined plane (fig. 22, left) equipped with moving egg elevator bars synchronized with the cross bars serving the single file conveyor belt. At the end of the incline each egg was deposited in turn into a set of notches of a pair of star-shaped wheels (fig. 23) whose rotation past and momentary hesitation at the light orifice of the detecting device (fig. 24) enabled each egg to be scanned momentarily. If blood was detected, a tripping mechanism diverted the egg to a conveyor leading to the reject tray (fig. 25, left) located in the grading booth next to the detector. The accepted eggs were released onto a belt conveyor running the length of the grading line. Each of four benches was equipped with a receiving tray into which eggs were diverted as needed by means of hand operated gates (fig. 25). Cartons were supplied to the graders by means of overhead chutes (fig. 25, top). Cartoned eggs were conveyed to the packer and packed from a rotary carton packing table (fig. 26).

Prototype Layout

The layout of the experimental line is shown in figure 5. Eggs were supplied to station No. 1 by conveyor and transferred to the spoolated conveyor

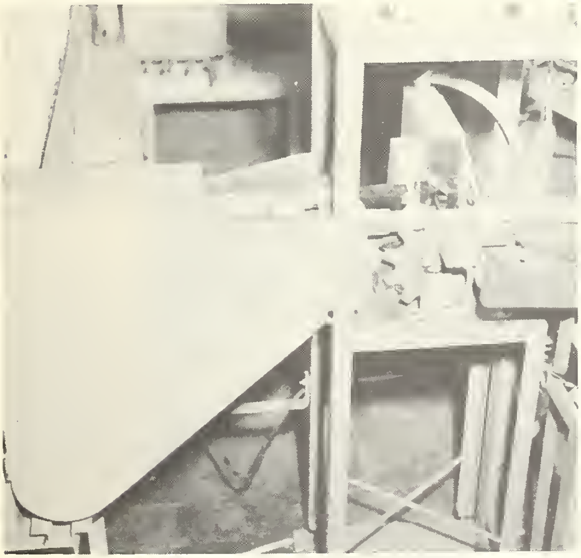


Figure 23.--Star-shaped wheels receive eggs for the detector (light shield removed).

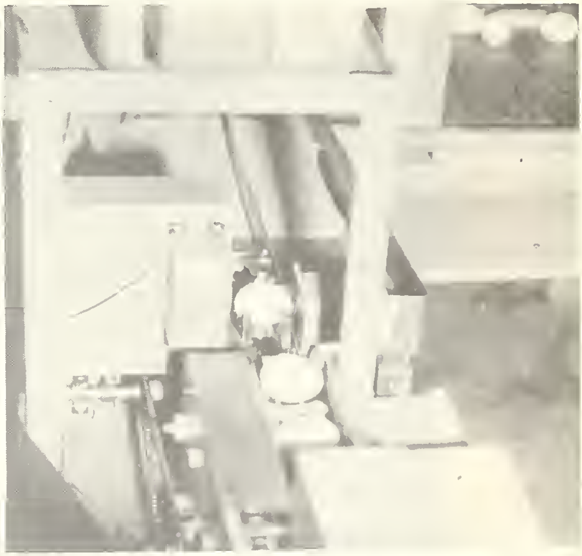


Figure 24.--Individual egg in position for scanning by detector (light shield removed).

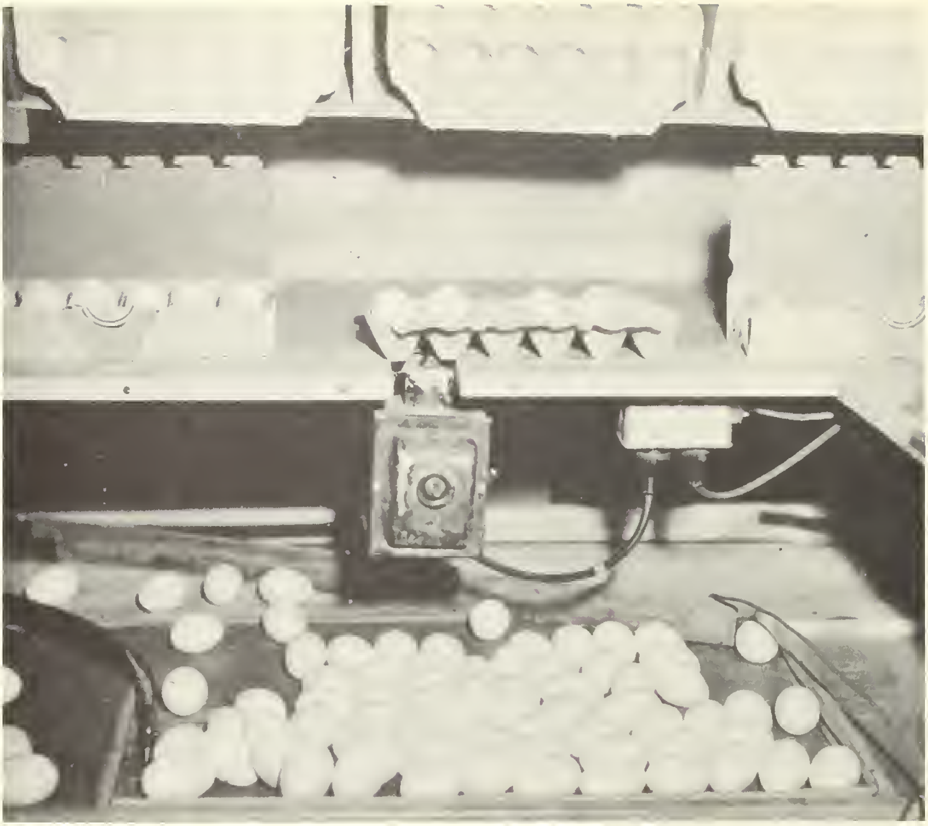


Figure 25.--Eggs with bloodspots (extreme left) have been rejected by detection; acceptable eggs are at right.

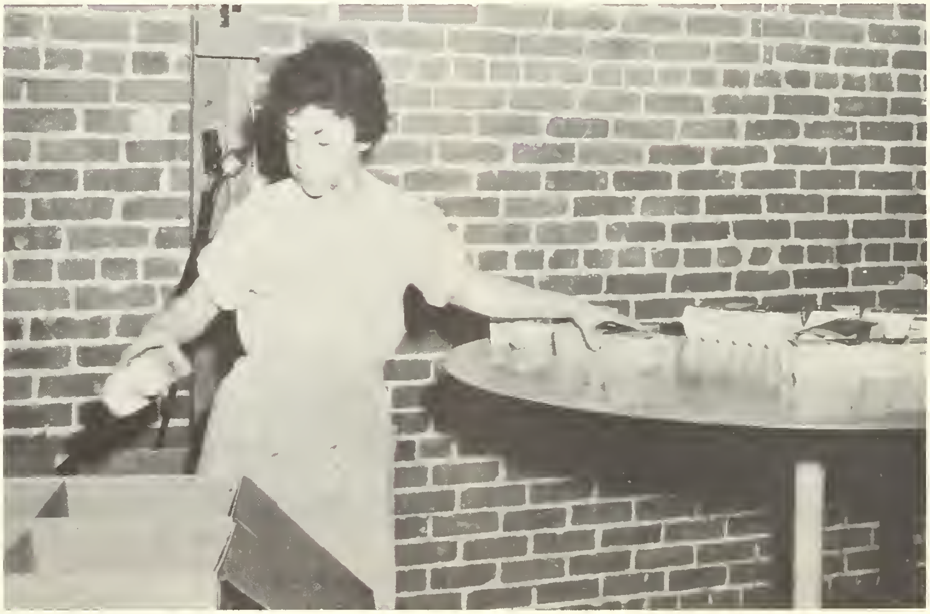


Figure 26.--Rotary carton packing table, experimental grading line.

in groups of 30. As eggs were loaded onto the conveyor, badly checked and dirty eggs were removed; as they passed over the underlit area, station No. 2, blind checks and opaque eggs were removed. A shelf extending the entire length of the conveyor was provided for reject eggs. After the eggs passed over the spoolated conveyor their 6 abreast formation was changed to single file by a singulator that fed the eggs into the detecting unit where acceptable eggs were discharged onto a 10-inch belt that conveyed them to the candling benches, stations Nos. 3, 4, 5, and 6, and bloodspots were diverted into the reject tray at station No. 3. The grading and packing booths as well as the carton packing table, station No. 7, replicated those used in system A, with the exception of slightly shorter side reaches and the method of conveying eggs to the graders.

Tests and Modifications

The prototype line differed only slightly from the original design. Some changes were necessitated because not all operating conditions could be foreseen prior to actual tests. Five test runs of 1 hour each under controlled conditions were conducted to make necessary adjustments in timing and to provide a smooth interchange of eggs between component parts of the system. The main modifications involved the underlit area of the infeed conveyor. In developing the most effective lighting for the proper detection of defective shells and opaque eggs, it was necessary to keep the light bright enough to adequately illuminate the eggs and yet not reflect into the eyes of the operator. The angle of reflection and the shield for blocking stray light rays that were finally developed are illustrated in figure 27.

Another difficulty was the proper positioning of eggs at the bloodspot detector. Eggs positioned themselves differently according to their size during the translation phase causing false detection signals or breakage. A change in the slope of the elevator from the singulator corrected this shortcoming somewhat. 4/ Excess breakage occurred as the eggs entered the receiving tray at the grading stations. The slope of the trays was adjusted frequently to obtain an optimum slope and the diversion gates and the receiving trays were lined with rubberized tape to reduce breakage.

One difficulty not overcome entirely was complete adaptation of the operators to changes in the grading procedure and equipment. Although a considerable period of time was spent in training the graders as to the proper handling of eggs and operation of equipment, it was difficult for them to overcome completely the grading habits of examining and re-examining an occasional egg for the presence of a bloodspot or to acquire the knack of using the egg diversion gates properly.

4/ Further improvement of the experimental commercial model of the detector is being carried on so that the position of eggs can be maintained more effectively.

CROSS SECTION OF CONVEYORIZED FLASH CANDLER

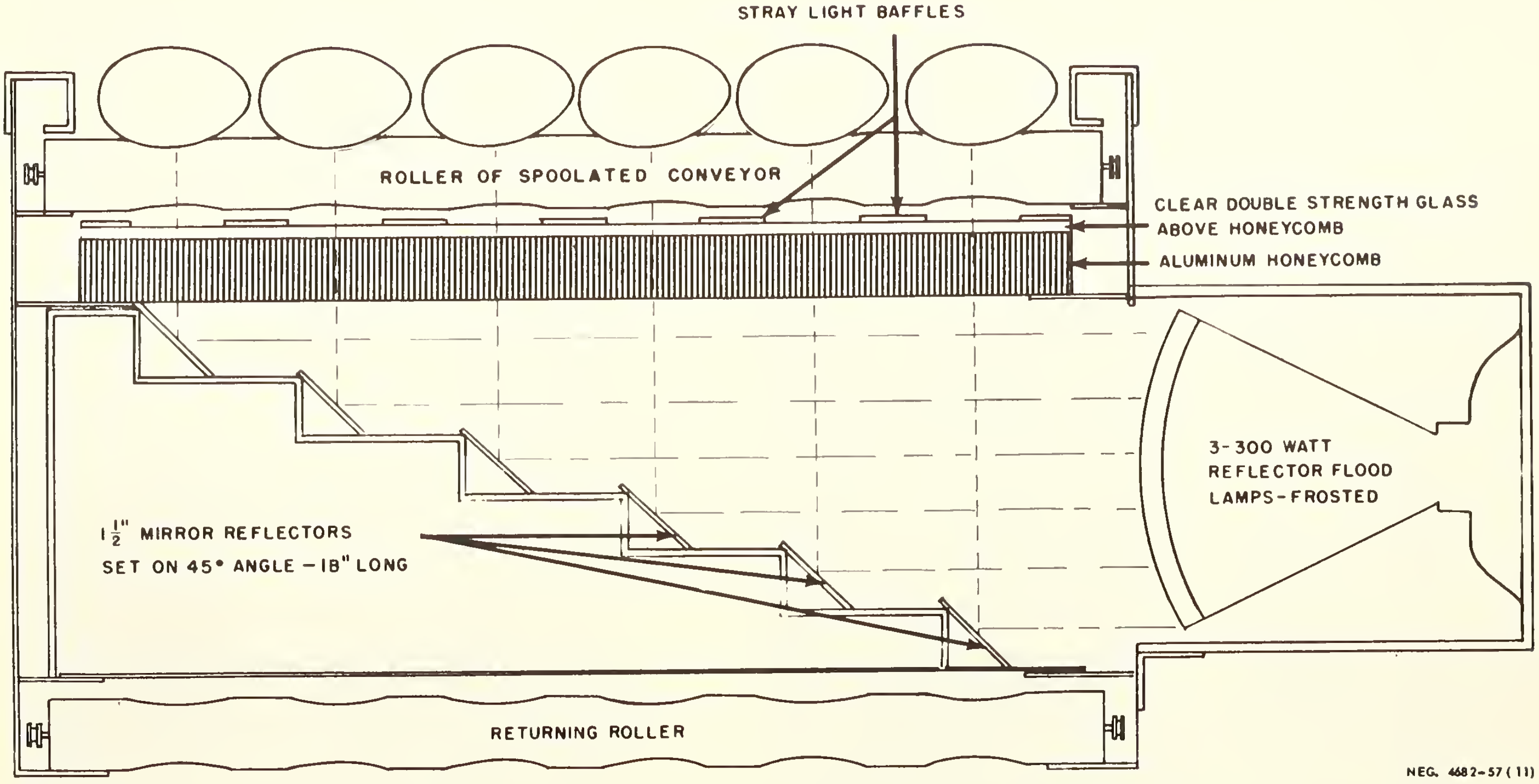

STRAY LIGHT BAFFLES
ROLLER OF SPOOLATED CONVEYOR
CLEAR DOUBLE STRENGTH GLASS ABOVE HONEYCOMB
ALUMINUM HONEYCOMB
3-300 WATT REFLECTOR FLOOD LAMPS-FROSTED
1½" MIRROR REFLECTORS SET ON 45° ANGLE - 18" LONG
RETURNING ROLLER
NEG. 4682-57 (11)

Figure 27.

ANALYSIS OF GRADING AND PACKING OPERATIONS UTILIZING ELECTRONIC BLOODSPOT DETECTION

Layout

The egg grading and packing operation involving system B was in the same room with, and located opposite, system A. It consisted of 4 grading stations in a row, fed at one end by a crossfeed flash candling conveyor and detector unit occupying an oblong space measuring approximately 16 feet by 38 feet (fig. 5). At the opposite end it was served by a double carton closing unit and cartoned egg packing table. Its location permitted convenient delivery of ungraded eggs and movement of graded product away from the packing area.

Flow of Product and Packing Materials

Flow of Product

The flow of ungraded product in the egg grading and packing operation employing electronic bloodspot detection was different in many respects from the flow of product in system A. The supply of eggs entered the system at a common loading point, passed through the electronic detecting unit and then to each grading bench by manually controlled egg diversion gates. The flow of graded product was the same in most respects as the flow in system A. It differed in that eggs containing blood were removed for the grader by the detector unit and diverted to a single packing station. Some of the undergrades and rejects were removed at the transfer and flash candling stations as the system was being loaded.

Flow of Packing Materials

The flow of packing materials was in most respects the same as the flow in system A. The small difference was the accumulation of filler-flats at the infeed conveyor during the transferring operation instead of at the grading benches and the graders required a few filler-flats supplied to them at their work station. The labor cost was insignificant.

Description and Analysis of Operation

Full Case Supplying

Full cases for system B arrived at the grading room floor by the same conveyor used for system A. Since the time required to supply both systems was small, no delays were caused by interference of flows. As full cases reached the grading floor, they were diverted to a gravity roller conveyor extending to the work station where eggs were transferred from the full cases to the system's infeed conveyor.

Approximately 8 minutes were required for a worker to supply the line with 100 cases. This was determined on the basis of requiring 0.13 man-hour of labor to divert 100 full cases of eggs to the conveyor.

Egg Transferring and Flash Candling

Full cases to be emptied onto the infeed conveyor were pulled into position from the gravity conveyor and their contents were transferred to the infeed conveyor by means of a multiple egg lifter in filler-flat quantities (30 eggs). In conjunction with this operation eggs were scanned under an overhead light for stained shells, and as they were rotated over an underlit portion of the conveyor they were inspected for shell defects or opaque content.

Analysis of the transferring and flash candling operation (figs. 20 and 21) shows that about 55 percent of the total time was spent in flash candling and 28 percent was spent in transferring eggs from case to conveyor (table 8).

Table 8.--Labor required by 1 worker to transfer 100 case loads onto infeed conveyor, flash candle and remove, and pack undergrade and reject eggs; system B, 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Handle full cases (100 cases from conveyor supplying system)	0.29	5.0
Remove empty flats	.54	9.3
Position empty flats for undergrade and reject eggs 2/	.02	.3
Transfer eggs and remove undergrade and reject eggs 3/	1.62	27.9
Flash candle and remove undergrade and reject eggs 4/	3.18	54.7
Pack undergrade and reject eggs	.01	.2
Handle full cases of undergrade and reject eggs	-	-
Handle empty cases	.13	2.3
Dispose of empty flats	.02	.3
Total labor	5.81	100.0

1/ Groups of 30 eggs by multiple lifter. Eggs showing opaque content, or dirty or defective shells are sought and removed at the underlit area.

2/ Assigned to flash candling.

3/ Eggs with dirty or dented shells were undergrades and smashed eggs were rejects.

4/ Eggs with blind checks were considered undergrades and opaque eggs were classified as rejects.

Grading and Packaging

In system B each grader intermittently diverted supplies of eggs into a receiving tray for grading and packaging (fig. 25). Over 90 percent of eggs were graded (see definition of terms in Appendix) and packed into cartons. The rest (undergrades and rejects) were packed into filler-flats at the transferring and flash candling station or the grading station and were collected at intervals for packing. It was possible to bulk pack all grades into filler-flats at the grading stations and remove them from the grading stations on the carton conveyor belt for assembly in case quantities at the end of the line, but figures for bulk packing were not obtained because the volume of eggs handled in this manner was insignificant. Cartons were obtained from the overhead carton chutes (fig. 25, top). Approximately one-half to three-quarters of a minute per case, or about 6 percent of the total time was spent in manipulating the egg diversion gates (table 9 and fig. 25).

Table 9.--Labor required by 1 worker to grade and package 100 cases of eggs of specified qualities at grading bench; system B 1/

Time item	Labor required when--		Percentage of total labor when--	
	60 to 80 percent of eggs are A quality	80 to 100 percent of eggs are A quality	60 to 80 percent of eggs are A quality	80 to 100 percent of eggs are A quality
	Man-hours	Man-hours	Percent	Percent
Grade eggs	17.84	16.32	85.6	84.4
Push full cartons onto belt and place empty cartons onto shelf.	2/ 1.80	2/ 1.80	8.6	9.3
Close and open egg flow control gate.	1.16	1.16	5.6	6.0
Position empty filler-flats	.05	.05	.2	.3
Total labor.	3/ 20.85	3/ 19.33	100.0	100.0

1/ 95.3 percent of the eggs delivered to the grading bench were packaged in molded pulp cartons and 4.7 percent in filler-flats.

2/ Requirement for chipboard cartons was 1.62 man-hours.

3/ The ratio of eggs graded and packaged at the grading benches to eggs fed into system averaged 96 out of every 100 (1.8 cases being removed by the flash candler and 2.2 cases being removed by the detector). Ninety-six percent of 20.85 man-hours is 20.02 man-hours, and 96 percent of 19.33 man-hours is 18.56 man-hours.

The average output per grader (grading and packaging) was about 4.8 cases per hour for large eggs of 60 to 80 percent A quality and about 5.2 cases per hour for 80 to 100 percent A quality, all at an acceptable level of workmanship. During operations involving irregular quality the graders occasionally required help from the packer or carton supplier. At both quality levels approximately 85 percent of the grader's time was spent in grading eggs. When the materials handling portion of the operation was omitted from the time figure, approximately 5.6 cases were graded at the 60 to 80 percent A quality and 6.1 cases per hour at the 80 to 100 percent A quality level. The next largest element was the operation of closing and opening the egg diversion gate, amounting to about 6 percent of the total time (table 9).

Because requirements called for at least 80 percent A quality in consumer grade A, it was necessary to examine individual eggs before the candling light in order to segregate the 60 to 80 percent A quality level eggs properly into their component qualities. Although the same procedure was followed with 80 to 100 percent A quality the findings indicated that it was unnecessary.

Packaging Eggs Employing Only Flash Candling and Electronic Detection of Bloodspots; System B

Based on the assumption that the ungraded product was of uniform high quality (80 to 100 percent A quality) and bloodspots and undergrades (checked and dirty shells) were detected and removed by flash candling and electronic detection, there seemed to be little economic justification for also individually examining each egg before the candling light. Inspection of the product after packaging justified this premise within the limits of the study.

Eggs arriving in egg receiving trays at the grading stations were transferred directly into cartons. Total labor required for the operation was 9.27 man-hours (table 10). Transferring eggs into cartons required 66 percent of the total labor.

Undergrade and Reject Packing

This operation was handled by the carton packer intermittently after collecting undergrades and rejects from the flash candling station and grading benches. The man-hours involved were relatively insignificant because of the low frequency of undergrade and reject occurrence. The labor required for collecting and packing 100 cases of undergrades and rejects amounted to 6.26 man-hours. At an undergrade and reject frequency of 6.7 cases per 100 cases graded, it amounted to only 0.42 man-hour, and 46 percent of this time was spent collecting rejects from detector reject tray (table 11).

Table 10.--Labor required by 1 worker to package 100 cases of eggs; system B 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Transfer eggs to cartons	6.12	66.0
Push full cartons onto belt and place empty cartons onto shelf	1.88	20.3
Close and open egg flow control gate	1.16	12.5
Obtain and position empty flats for undergrade eggs	.01	.1
Transfer eggs to flats	.10	1.1
Total labor	2/ 9.27	100.0

1/ Approximately 99 percent of the eggs delivered to the grading bench were packaged in cartons; 1 percent in filler-flats. Eggs previously flash candled, and bloodspots removed by electronic bloodspot detector.

2/ The ratio of eggs packaged to eggs fed into the system averaged 96 out of every 100 (1.8 cases being removed by the flash candler and 2.2 cases by the detector). Ninety-six percent of 9.27 man-hours is 8.9 man-hours.

Table 11.--Labor required by 1 worker to collect and pack 100 cases of undergrade and reject eggs; system B 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Handle empty cases	0.18	2.9
Collect reject eggs from detector reject tray	2.90	46.3
Collect undergrade eggs from grading benches	1.48	23.6
Pack undergrade and reject eggs	1.17	18.7
Handle full cases	.18	2.9
Walk empty	.35	5.6
Total labor	2/ 6.26	100.0

1/ Approximately 1/3 of all eggs collected and packed were reject eggs from detector; 2/3 were undergrade eggs from grading benches.

2/ Rate of accumulation of reject and undergrade eggs at detector and grading benches was 6.7 cases per 100 cases input to the system (0.42 man-hour). When eggs were submitted to flash candling and electronic bloodspot detection only, the rate of undergrade accumulation at the packaging station dropped to 1 case per 100 cases of input. Thus with the 2.2 cases per 100 accumulation rate at the detector it would require 10.2 man-hours to collect and pack 100 cases of undergrades and rejects.

Carton Making and Supplying

The time required to handle bundles and boxes of cartons and time required to make up cartons and machine wait time (chipboard cartons) was identical to the requirements in system A. The time required to walk to, load carton chutes, and return to the carton make up station was 0.16 hour for molded pulp and 0.83 for chipboard cartons. As in system A, (table 4, and Appendix table 22), the labor required for making and supplying the chipboard cartons was greater than for molded pulp cartons (table 12, and Appendix table 23); therefore, only the figures for molded pulp were used for comparative purposes.

Table 12.--Labor required by 1 worker to prepare and distribute the equivalent of 100 cases of molded pulp cartons; system B 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Handle bundles of cartons	0.15	48.4
Walk to and load carton chutes.	.10	32.2
Walk empty.	.06	19.4
Total labor.	0.31	100.0

1/ Production rate of cartoned eggs when grading averaged 2,750 dozen per 100 cases of ungraded input, requiring 0.28 man-hour labor, and 2,850 dozen when flash candling only, requiring 0.29 man-hour labor.

Carton Packing

This operation was identical to the operation in system A. Table 13 shows that carton packing for the equivalent of 100 cases required 2.02 hours in system B. When computed at the actual rate at which eggs were cartoned in 100 cases of eggs graded (91.5 cases) the required labor amounted to 1.85 man-hours. Approximately 74 percent of the worker's time was spent in packing cartons of eggs into cases.

Cost Analysis of System B

Labor requirements and labor and equipment costs were determined for two levels of product quality, i.e., 60 to 80 percent A quality and 80 to 100 percent A quality, because of the difference in labor requirements at these levels. Labor and equipment costs were also determined for the operation when eggs known to be of 80 to 100 percent A quality were flash candled only, omitting the examination of each egg before the candling light.

Table 13.--Labor required by 1 worker to pack 100 cases of cartoned eggs into 30-dozen fiber cases; system B 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Handle empty cases	0.24	11.9
Pack cartons	1.50	74.2
Handle full cases	.27	13.4
Supply empty cases to undergrade and reject packing bench 2/	.01	.5
Total labor	2.02	100.0

1/ Production rate of cartoned eggs when grading was 91.5 cases per 100 cases of ungraded input, requiring 1.85 man-hours labor, and 95 cases when flash candling only, requiring 1.92 man-hours labor. Molded pulp or chipboard cartons were used.

2/ The 6.7 empty cases required for undergrades and rejects in this operation are passed to the reject packer as necessary.

Sixty to Eighty Percent A Quality

Grading and packaging labor (table 14), including the labor required for flash candling (table 8), constitutes 76.4 percent of the total labor requirements in a 6-man crew handling 100 cases in 5.65 hours of elapsed time. Flash candling accounts for 13.7 percent of these time items. Hourly output of each of the 3 graders is 5 cases plus a prorated portion of the production of 2 workers who assist. Idle time represents 5.2 percent of the total time.

In 5.65 hours of elapsed time a 6-man crew required 30.38 man-hours and 5.65 machine-hours to grade and package 100 cases of large eggs of 60 to 80 percent A quality in filler-flats and molded pulp cartons, and pack the cartons into 30-dozen fiber cases by system B. Labor and equipment costs are summarized in table 18, page 44.

The crew handled this operation as follows: 1 worker transferred and flash candled eggs; 3 workers graded and packaged eggs; 1 worker supplied cartons, assisted graders and flash candler; and 1 worker packed cartoned eggs into cases, packed rejects into cases, and assisted graders.

Table 14.--Labor required for a 6-man crew to grade and package 100 cases of large eggs, 60 to 80 percent A quality, into filler-flats and molded pulp cartons and pack into 30-dozen fiber cases; system B 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Productive labor:		
Full case supplying	2/ 0.13	0.4
Flat transfer and flash candling. . .	3/ 5.81	19.1
Grading and packaging	4/ 20.02	65.9
Undergrade and reject packing	.42	1.4
Carton supplying.	5/ .28	.9
Carton packing.	1.85	6.1
Walking to assist graders (carton packer and carton supplier).	6/ .30	1.0
Total productive labor	28.81	94.8
Unproductive labor:		
Carton packer waits on worker who transfers flats and flash candles. .	1.57	5.2
Total labor.	30.38	100.0
Elapsed hours.	5.65	

1/ Crew organization: 1 worker transfers flats and flash candles eggs, 3 workers grade and package eggs, 1 worker supplies cartons, assists at flash candling station and assists graders, 1 worker packs cartons and undergrade and reject eggs and assists graders.

2/ Full case supplying is not a function of the system; therefore, this worker is not included as a crew member. However, since the labor is required to enable the system to operate it is included as part of the total labor with no idle time involved.

3/ 3.18 hours required for flash candling (table 8) of which 0.16 hour is provided by the carton supplier.

4/ 1.61 hours by carton packer, 1.46 hours by carton supplier and 5.65 hours for each of the three graders.

5/ Carton supplier also performed other duties not evaluated in this study; idle time not involved.

6/ Carton packer must walk 0.2 hour and carton supplier 0.1 hour.

Labor costs for the operation, computed at $1.68 per hour (Appendix, page 48) were $51.04; equipment costs computed at $1.92 per hour (Appendix, page 48 and table 20) $10.85; total $61.89. The total cost per case then is approximately 62¢. Of this amount, 51¢ is labor cost. Of the total labor cost per case, approximately 39¢ represents grading, packaging and flash candling labor, while 33½¢ is for grading and packaging labor.

Eighty to One Hundred Percent A Quality

Grading and packaging labor (table 15), including the labor required for flash candling (table 8), constitutes 75.4 percent of the overall grading and packing labor. Flash candling at the system's loading station accounts for 14.6 percent of these time items. The average hourly output of each of the 3 graders is 5.4 cases plus a prorated portion of the production of 2 workers who assist. Idle time represents 5.4 percent of the total labor required.

Table 15.--Labor required for a 6-man crew to grade and package 100 cases of large eggs 80 to 100 percent A quality, into filler-flats and molded pulp cartons and pack into 30-dozen fiber cases; system B 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Productive labor:		
Full case supplying	2/ 0.13	0.5
Flat transfer and flash candling. . . .	3/ 5.81	20.2
Grading and packaging	4/ 18.56	64.4
Undergrade and reject packing	.42	1.5
Carton supplying.	5/ .28	1.0
Carton packing.	1.85	6.4
Walking to assist graders (carton packer).	.20	.7
Total productive labor. . . .	27.25	94.6
Unproductive labor:		
Carton packer waits on worker who transfers flats and flash candles. . .	1.57	5.4
Total labor	28.82	100.0
Elapsed hours	5.65	

1/ Crew organization: 1 worker transfers flats and flash candles eggs, 3 workers grade and package eggs, 1 worker supplies cartons and assists at flash candling station, 1 worker packs cartons and undergrade and reject eggs and assists graders.

2/ Full case supplying is not a function of the system; therefore, this worker is not included as a crew member. However, since the labor is required to enable the system to operate it is included as part of the total labor with no idle time involved.

3/ 3.18 hours required for flash candling (table 8) of which 0.16 hour is provided by the carton supplier.

4/ 1.61 hours by carton packer and 5.65 hours for each of the 3 graders.

5/ Carton supplier also performed other duties not evaluated in this study; idle time was not involved.

In 5.65 hours of elapsed time a 6-man crew required 28.82 man-hours of labor and 5.65 machine-hours to grade and package 100 cases of large 80 to 100 percent A quality eggs in filler-flats and molded pulp cartons and to pack the cartons into 30-dozen fiber cases by system B. Labor and equipment costs are summarized in table 18, page 44.

The crew handled this operation as follows: 1 worker transferred flats onto the infeed conveyor and flash candled eggs, 3 workers graded and packaged eggs, 1 worker supplied cartons and assisted at the flash candling station, and 1 worker packed cartons, undergrade and reject eggs and assisted the graders.

Labor costs for the operation, computed at $1.68 per hour (Appendix, page 48) were $48.42; equipment costs computed at $1.92 per hour (Appendix, page 48 and table 20) $10.85: total $59.27. The total cost per case under this condition then amounts to approximately 59¢ per case of which about 48½¢ represents labor and the balance is for equipment.

Flash Candling 80 to 100 Percent A Quality

Based on company records and inspection findings, egg production from selected flocks that regularly yielded uniformly high percentage of top qualities was used in a test that omitted the manual examination of individual eggs before the candling light in system B.

Where the manipulation of individual eggs before the candling light was omitted and only a flash candling type of grading was performed, grading labor was reduced to 3.18 man-hours and total labor was reduced to 19.32 hours (table 16).

In 5.65 hours of elapsed time a 4-man crew required 19.32 man-hours and 5.65 machine-hours to flash candle and package 100 cases of large 80 to 100 percent A quality eggs in filler-flats and molded pulp cartons and pack cartons into 30-dozen fiber cases by system B. Labor and equipment costs are summarized in table 18, page 44.

The crew handled this operation as follows: 1 worker transferred flats and flash candled eggs: 1 worker packaged eggs; 1 worker supplied cartons to the packager and assisted at that station and the flash candling station; 1 worker packed cartons, undergrades, and rejects into cases and assisted at the packaging station.

Labor costs for the operation computed at $1.68 per hour (Appendix, page 48) were $32.46; equipment costs at $1.92 per hour (Appendix, page 48 and table 21) $10.40; total $42.86. The total cost per case then is about 43¢. The only grading labor required involved 3.18 hours (table 8) for flash candling amounting to $5.34 or 16½ percent of the total labor cost. The 9¼ hours required to package 100 cases (table 10) amounted to 15½¢ per case for labor or slightly less than one-half of the labor cost for the overall operation.

Table 16.--Labor required for a 4-man crew to flash candle and package 100 cases of large eggs 80 to 100 percent A quality into filler-flats and molded pulp cartons and pack into 30-dozen fiber cases; system B 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Productive labor:		
Full case supplying	2/ 0.13	0.7
Flat transfer and flash candling	3/ 5.81	30.1
Packaging	4/ 8.90	46.1
Undergrade and reject packing	.33	1.7
Carton supplying	5/ .29	1.5
Carton packing	1.92	9.9
Walking to assist packager (carton packer and carton supplier)	6/ .35	1.8
Total productive labor	17.73	91.8
Unproductive labor:		
Carton packer waits on worker who transfers flats and flash candles	1.59	8.2
Total labor	19.32	100.0
Elapsed hours	5.65	

1/ 80 to 100 percent A quality determined by random sample inspection. Crew organization: 1 worker transfers flats and flash candles eggs, 1 worker packages eggs, 1 worker supplies cartons, assists at flash candling station, and assists packager, 1 worker packs cartons and undergrade and reject eggs and assists packager.

2/ Full case supplying is not a function of the system; therefore, this worker is not included as a crew member. However, since the labor is required to enable the system to operate it is included as part of the total labor with no idle time involved.

3/ 3.18 hours required for flash candling (table 8) of which 0.16 hour is provided by the carton supplier.

4/ 1.61 hours by carton packer, 1.64 hours by carton supplier and 5.65 hours by worker packaging eggs.

5/ Carton supplier also performed other duties not evaluated in this study; idle time was not involved.

6/ Carton packer must walk 0.2 hour and carton supplier 0.15 hour.

COMPARISON OF SYSTEMS A AND B

Layout of Systems

Basically, the two systems differed in the shape of the area required to accommodate their layout. System A required an oblong rectangular shape whereas a more nearly square area was required for system B. System A required a major service area at one end of the line for packing the upper grades of product and a minor service area at the opposite end for undergrades. It required a supply service area along the entire length of the line to furnish ungraded product to the graders. Work in this area sometimes interfered with the job of furnishing cartons to the graders. System B, on the other hand, required only one packing service area for all graded product at one end of the line and one supply service area at the other end to furnish ungraded product for the entire system. Work in one of the service areas did not conflict with work in the other.

The square feet of floor space required per unit (case) of product packed per 8-hour day favored system A which required about 6 square feet whereas system B required approximately 8 square feet per case per 8-hour day (fig. 5). The grading benches were similar except that in system B they were shorter and provided more convenient reaches than those for like operations in system A. The carton packing area in system B was smaller in floor space requirements than system A because of the smaller volume moving through the system.

Flow of Product and Packing Materials

Packing Materials

The flow of empty cartons in the two systems was about the same. The only difference was a slightly more direct and shorter route in system B as noted in the small saving in walk time (tables 4 and 12). Empty filler-flats followed a different flow pattern in system A as compared with system B. In system A they moved with the eggs to 9 grading stations. After they were emptied they were stacked beside the grader until a stack of about 35 was accumulated. The stack was then moved to the outside of the bench for later pickup by another worker. In system B all filler-flats were assembled at one point as they were emptied by the worker supplying the system with eggs.

Product

Basically, the flow of product in the two systems differed as follows: (1) Product entered system A at 9 different points; whereas, in system B it entered at one point; (2) product moved directly to each grader in system A whereas in system B it was diverted from a common supply by opening and closing diversion gates when eggs were needed; and (3) in system B some undergrades and most of the rejects were diverted away from the grading line at a flashing station and by a detector unit.

The flow of cartoned product to the carton packer and away from the carton packing area was almost identical in both systems.

Operations

The operations of supplying cartons to the two systems were similar. Some time and effort was saved in system B because of easier reach to carton chutes (tables 4 and 12), and as previously mentioned in the comparison of flows, walk time was decreased somewhat in system B because of a shorter and more direct route.

Supplying the systems with eggs was entirely different in each system in that the worker on this job in system B also removed undergrades and rejects (flash candling)--an additional time item that represented over 50 percent of the labor requirements for the job. Other differences between systems in this operation were: (1) A multiple egg lifter transfer device was used to remove eggs from the case in system B, adding about 1 man-hour of labor per 100 cases; and (2) walk time was eliminated in system B, reducing required labor by two-thirds of a man-hour.

The grading and packaging operation differed between systems, too. In system A the grading of eggs took place at the grading stations only; whereas, in system B grading in the form of flash candling (removing some rejects and undergrades) was performed by the worker loading the system, and most of the remaining rejects were removed by the electronic detecting device. Although this assistance to the grader reduced the required labor at the grading bench by almost 4 hours for 100 cases of 60 to 80 percent A quality, and about two-thirds of an hour for 100 cases of 80 to 100 percent A quality (tables 2 and 9), it had an opposite influence on the overall cost (table 18), because of higher equipment costs.

In the remaining operations, undergrade and reject handling and carton packing, the difference in labor requirements was so small as to be insignificant.

When the candling of individual eggs was omitted from the operation in system B during the time eggs of 80 to 100 percent A quality were handled, the workers at the grading and packaging benches merely transferred eggs directly from receiving trays into cartons. Thus the total labor requirement for the operation was reduced by more than 5 man-hours.

Quality of Workmanship

The quality of worker performance was evaluated in both systems to determine the effectiveness with which bloodspots were removed and the accuracy with which the graders classified the remaining eggs within required quality limits. Accuracy of bloodspot detection was checked both as to candled and broken out appearance by licensed USDA graders. Quality factors other than blood were also checked by candled appearance. The relative effectiveness of electronic bloodspot detection as compared with detection by a grader, based on inspection by conventional commercial candling light involving over 36,000 eggs, indicated the accuracy of detecting bloodspots electronically was approximately 9 times more effective than when human detection was employed. In doing so, the detector rejected eggs at a rate about 14 times as great as the human rejection rate (table 17). A more time consuming but more accurate inspection involved a broken out test of over 10,000 eggs. It showed that the electronic operation was approximately twice as effective in detecting bloodspots as the human operation. In doing so, the detector rejected eggs at a rate about 5 times as great as the human grader (table 17).

Table 17.--Comparison of accuracy of visual bloodspot detection and electronic detection based on inspection by candling and broken out tests 1/

Means of detection	Number of			Rate of missed bloodspots per 1,000 eggs 3/
	Eggs examined for blood	Eggs rejected 2/	Bloodspots missed	
Candling test:				
Human detection	15,400	33	61	3.9
Electronic detection. .	21,300	468	8	.38
Broken out test:				
Human detection	5,352	40	45	8.4
Electronic detection. .	5,415	214	27	5.0

1/ Including bloodspots 1/8" in diameter and larger. Each egg in the candling tests was inspected for the presence of blood before the candling light by a USDA inspector (fig. 2) after having been classified by the grader. In the broken out tests each egg was broken out and the egg content examined for the presence of bloodspots (fig. 3).

2/ A monetary evaluation of the market value of the clear eggs rejected as bloodspots in relation to the overall costs was not carried out because the inaccuracies of rough approximations would have been involved.

3/ A determination of the effect that a reduction of the incidence of bloodspots would have on the value of graded eggs was not made because the factors involved extend beyond the scope of this study.

During the inspection for bloodspots before the candling light, graded eggs were also segregated as to their qualities to exclude data involving lots in which the tolerances for graded product did not fall within the prescribed acceptance range. In more than 100 cases of eggs (more than 36,000 eggs) involving lots of one or more cases per study, there were no lots in which the graders' inaccuracy in proper segregation of qualities required elimination of the data because of excess tolerances.

There were, however, a number of lots that were excluded from consideration in the computation of data because of an excessive quantity of undergrades or bloodspots in an occasional case of ungraded product or because of extreme variations in time study data.

Labor and Equipment Costs

At 60 to 80 percent A quality level it required 20¢ less labor (table 18), to grade and pack 100 cases of eggs in system B than in system A. The small economic advantage gained through labor savings at this quality level was more than offset by equipment costs that were almost twice as much per case as system A (table 18). The higher equipment cost due largely to the rental costs for the detector (tables 20 and 21) resulted in an increased total cost of 5¢ per case.

Where the quality of the eggs handled was 80 to 100 percent A quality, the labor cost for grading and packing in system B was 7¢ more per case than for system A. The cost was increased further by greater equipment cost that was 6¢ per case higher than system A, for a total increase in cost of 13¢ per case.

Where the candling of individual eggs was omitted while handling 80 to 100 percent A quality in system B and grading labor was confined to flash candling, the labor costs were decreased by almost 9¢ per case, when compared with the grading and packing labor required in system A for the same quality, and the reduction in total costs was 3¢ per case.

Thus when total costs for grading and packing like qualities by specified methods in either system was compared, it was noted that grading and packing 60 to 80 percent A quality cost $4.86 more per 100 cases in system B and $13.27 more per 100 cases for 80 to 100 percent A quality. When the method in system B was modified to exclude the candling of eggs individually for 80 to 100 percent A quality, it cost $3.14 less per 100 cases for system B (fig. 28).

CONCLUSIONS

Based on a test involving the broken out appearance of individual eggs the electronic bloodspot detector did the job of detecting and rejecting eggs containing bloodspots twice as effectively as the human eye and based on a test involving the candled appearance it was 9 times more effective. The detector operating speed during the test averaged 17.7 cases per hour, setting the pace for the work crew. Although this automatically set rather inflexible limits on the crew size it indicated adaptability to small as well as to large volume operations--the lower limit being 141 cases per day and the upper limit approximating any multiple of the figure.

Table 18.--Comparative labor and equipment costs for grading and packing 100 cases of large eggs of indicated qualities by specified methods and equipment 1/

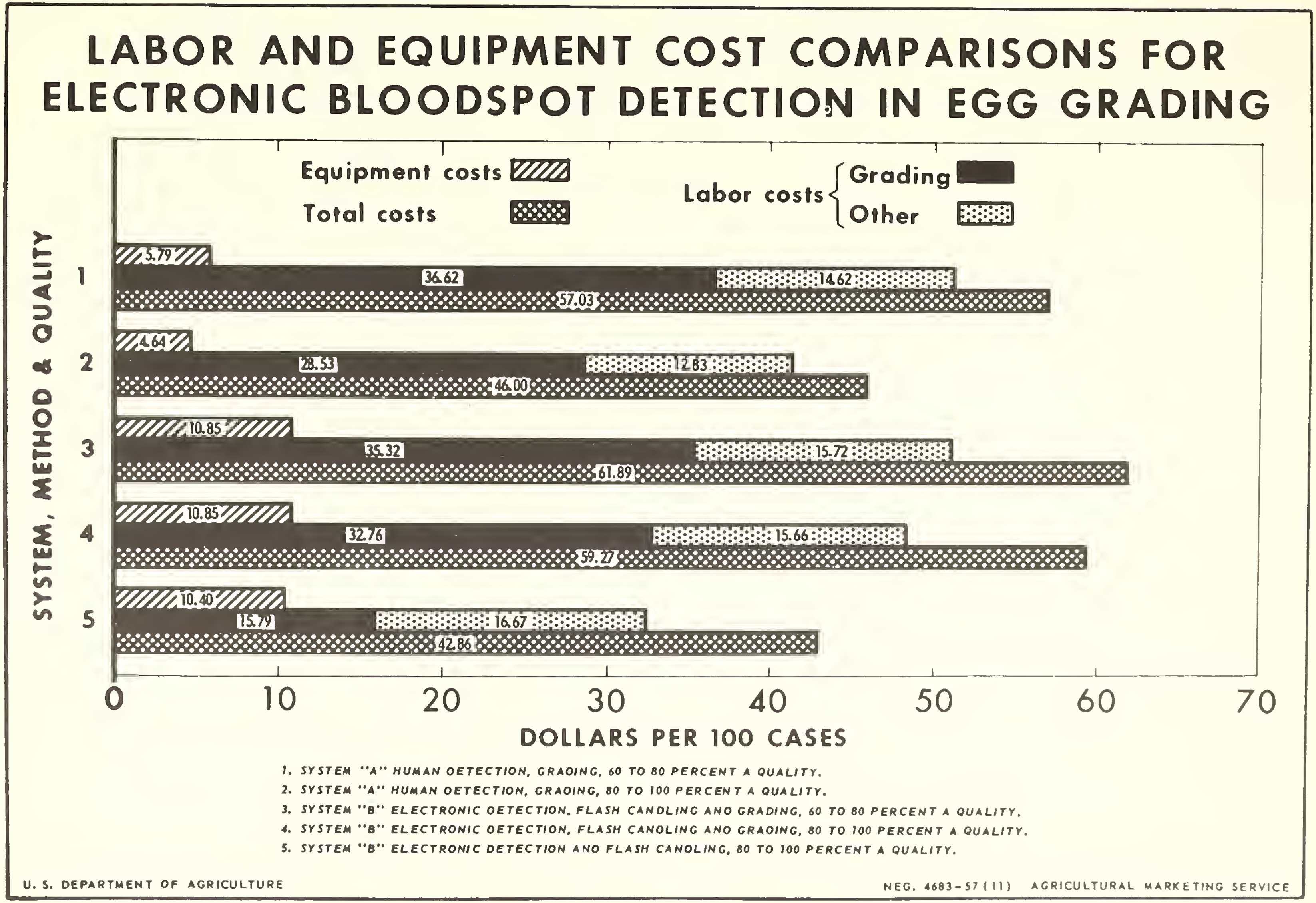
Method and egg quality	Crew size	Elapsed time	Labor and equipment required		Labor and equipment costs		
			Labor	Equipment	Labor	Equipment	Total
	Number	Hours	Man-hours	Machine-hours	Dollars	Dollars	Dollars
60 to 80 percent A quality-grading with human detection of bloodspots--system A.	13	2.68	30.50	2.68	51.24	2/ 5.79	57.03
80 to 100 percent A quality-grading with human detection of bloodspots--system A.	13	2.15	24.62	2.15	41.36	2/ 4.64	46.00
60 to 80 percent A quality-grading after flash candling and electronic bloodspot detection--system B	6	5.65	30.38	5.65	51.04	3/10.85	61.89
80 to 100 percent A quality-grading after flash candling and electronic bloodspot detection--system B	6	5.65	28.82	5.65	48.42	3/10.85	59.27
80 to 100 percent A quality-flash candling and electronic bloodspot detection--system B. .	4	5.65	19.32	5.65	32.46	4/10.40	42.86

1/ Annual volume sufficient to provide 2,000 hours use.

2/ Equipment consisted of 9 grading benches equipped with crossfeed egg conveyors, transfer tables, carton chutes, 1 undergrade and reject packing bench, 1 carton conveyor belt, 1 drive unit, 2 carton closers, 1 carton packing table, 1 carton shaker, and roller and skate conveyors serving the system at an hourly rate of $2.16 per hour for an assumed annual use of 2,000 hours (table 19, Appendix).

3/ Equipment consisted of 1 spoolated conveyor, 1 electronic bloodspot detector, 4 grading benches equipped with carton chutes, 1 carton conveyor belt, 2 carton closers, 1 carton packing table, 1 carton shaker, and roller and skate conveyors serving the system at an hourly rate of $1.92 per hour for an assumed annual use of 2,000 hours (table 20, Appendix).

4/ Equipment consisted of 1 spoolated conveyor, 1 electronic bloodspot detector, 2 grading benches equipped with carton chutes, 1 carton conveyor belt, 2 carton closers, 1 carton packing table, 1 carton shaker, and roller and skate conveyors serving the system at an hourly rate of $1.84 per hour for an assumed annual use of 2,000 hours (table 21, Appendix).



LABOR AND EQUIPMENT COST COMPARISONS FOR ELECTRONIC BLOODSPOT DETECTION IN EGG GRADING

1. SYSTEM "A" HUMAN DETECTION, GRADING, 60 TO 80 PERCENT A QUALITY.
2. SYSTEM "A" HUMAN DETECTION, GRADING, 80 TO 100 PERCENT A QUALITY.
3. SYSTEM "B" ELECTRONIC DETECTION, FLASH CANDLING AND GRADING, 60 TO 80 PERCENT A QUALITY.
4. SYSTEM "B" ELECTRONIC DETECTION, FLASH CANDLING AND GRADING, 80 TO 100 PERCENT A QUALITY.
5. SYSTEM "B" ELECTRONIC DETECTION AND FLASH CANDLING, 80 TO 100 PERCENT A QUALITY.

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Figure 28.

When electronic bloodspot detection was used the eggs had to be flash candled before they were subjected to electronic detection in order to remove checked eggs that might break during the operation and opaque blood eggs that could be passed as acceptable by the detector. Consumer grade requirements of 80 percent A quality minimum called for full candling in addition to flash candling where 60 to 80 percent A quality was being handled. At this quality level the added expense of flash candling was more than offset by a decrease in the cost for full candling at the grading benches. The saving in grading labor was, however, more than offset by an increase in equipment cost due largely to the detector rental rates. The additional overall cost for electronic detection of bloodspots was 5 cents per case. Since the rental rates decrease as the volume increases consideration should be given to taking advantage of the low rental rate for large volume by working the detector for more than one work shift per day.

When eggs were in the 80 to 100 percent A quality bracket more grading labor was involved when electronic detection was used. This was due to the fact that savings in labor at the grading benches were insufficient to offset the additional labor for flash candling and higher equipment cost. Thus the total cost was increased by 13 cents a case when compared with conventional grading.

Inspections showed that when the higher quality eggs from selected flocks were being handled, effective removal of excess undergrades by flash candling and removal of eggs containing bloodspots by electronic detection eliminated the need for further candling to meet grade requirements. The operation was therefore analyzed without the examination of each egg before the candling light. The results showed that grading labor costs were reduced sharply. Even though all other labor remained at about the same level, and equipment cost was higher, eggs were graded and packed for 3 cents a case less than when regular grading was employed.

From this limited study at one plant, conducted under specific product and operating conditions, it is concluded that the electronic bloodspot detector can: (1) Improve detection and removal of eggs containing bloodspots in lots of white eggs of 60 to 80 percent A quality at a small saving in grading labor but at a total increase in cost of about 5 cents a case; (2) improve detection and removal of eggs containing bloodspots for lots averaging 80 to 100 percent A quality at an additional cost of 13 cents a case; (3) improve detection and removal of eggs containing bloodspots in lots from selected flocks averaging 80 to 100 percent A quality, and by omitting full candling, reduce grading labor 50 percent, thereby reducing total cost by 3 cents a case; and (4) possibly save the industry up to one million dollars per year, on the assumption that at least 20 percent of the annual United States production orginates from commercial poultry farms with controlled flocks that produce white eggs in the 80 to 100 percent A quality limit at the time of grading and packing for the consumer.

The findings of this test indicate that: (1) Detection of bloodspots in eggs with white shells can be accomplished effectively and economically by electronic device within the egg quality, equipment, and method limitations of this study; (2) further tests are necessary to determine the scope of the applicability of the findings under various operating conditions and product qualities; and (3) the development and introduction of semiautomatic or automatic packaging equipment is warranted because the handling of individual eggs is eliminated with the use of flash candling and electronic detection.

Trial tests of modified packaging station layout and equipment on the experimental line are now underway in order to locate flaws that might develop at commercial operating speeds in equipment that arranges egg alignment into position patterns suitable for rapid manual egg transfer into cartons. Preliminary estimates indicate that a considerable decrease in packaging labor can be expected from these changes. Further modifications planned include an in-line automatic sizing device capable of segregating eggs into 5 size classes at 20 cases per hour intergrated with equipment being developed to automatically or semiautomatically carton eggs. After these modifications have been completed and a moderately smooth operation at commercial operating speeds is developed tests will be conducted to determine the additional savings that might result. The findings will be published as a second part of the study in mechanization in commercial egg grading and packing.

APPENDIX

Equipment Costs

In order to obtain a meaningful comparison of equipment costs for systems A and B, the initial cost of system A was obtained from company records and the cost for system B was synthesized by using the cost figures of system A components that were comparable to parts used in system B plus an estimate of cost for parts in the system that had to be developed for the test. The ownership and operating cost of equipment was based on 2,000 hours of annual use with specified crew sizes (tables 19, 20, and 21). Because periods of machine inactivity were brief and infrequent, equipment was considered to be in use the entire time. The company's depreciation rates of 10 percent per annum for the carton shaker and 1 percent per month for the balance of the equipment were used. They were based on useful life and obsolescence. Interest was calculated at 5 percent of half of the initial investment and insurance and taxes were estimated at 4 percent of initial cost. Power costs were based on 1956 rates. Maintenance cost was based on plant expenditures during the year 1956.

Labor Costs

The hourly wage rate for all employees at both systems was calculated at $1.68 per hour. This figure included an average base wage rate of $1.56 per hour plus the cost of vacation pay, insurance, pension, State unemployment, F.I.C.A., workmen's compensation, and average cost of personal equipment. Neither system was charged for management cost.

Relationship of Egg Quality to Grading Time and Accuracy

The necessity for dividing the study according to egg quality ranges is demonstrated in figure 29 which illustrates consistently higher time values for eggs in the lower quality bracket. In instances where an occasional point on the chart showed a variation from the average, adjustment for grading accuracy reduced the variation sufficiently to permit retention of the data.

Definitions of Terms

The terms used to discuss the analysis and findings in this report are listed separately under two headings, titled "Egg Marketing Terminology" and "Industrial Engineering Terminology" in order to avoid confusion and for convenient reference not only for the reader unfamiliar with either field but also for the purpose of establishing the interpretations applied to the terms in this report.

Table 19.--Ownership and operating costs of grading and packing equipment based on a 13-man crew and 2,000 hours annual use, system A

Kind and amount of equipment	Initial cost 1/	Expected life	Ownership cost					Operating cost			Total annual cost	Total hourly cost
			Depreciation 2/	Interest 3/	Insurance and taxes 4/	Rent 5/	Total	Power 6/	Maintenance	Total		
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
9 egg grading benches 7/.	14,400.00	8.3	1,728.00	360.00	576.00	-	2,664.00	53.48	880.00	933.48	3,597.48	1.799
1 carton closer and and packing table.......	-	-	-	-	-	324.00	324.00	19.34	120.00	139.34	463.34	.232
1 carton shaker..........	425.00	10.0	42.50	10.63	17.00	-	70.13	5.80	24.00	29.80	99.93	.050
55 ft. of gravity conveyor (roller type).....	330.00	8.3	39.60	8.25	13.20	-	61.05	-	8/	-	61.05	.031
114 ft. of gravity conveyor (wheel type)......	570.00	8.3	68.40	14.25	72.80	-	105.45	-	8/	-	105.45	.052
Total..........											4,327.25	2.164

1/ Delivered plant cost.
2/ Based on company estimates of 10 percent per annum rate on the carton shaker and 1 percent per month on all other equipment.
3/ Interest at 5 percent of average investment (computed at 50 percent).
4/ Insurance and taxes assumed 4 percent of initial investment.
5/ Annual rate.
6/ 1956 rates, 1.45¢ per k.w.h.
7/ Including 10 grading lights, crossfeed egg conveyors, carton chutes, undergrade and reject packing bench carton conveyor belt and motor drive unit.
8/ Included in grading bench maintenance.

Table 20.--Ownership and operating costs of grading and packing equipment based on a 6-man crew and 2,000 hours annual use, system B

Kind and amount of equipment	Initial cost 1/	Expected life	Ownership cost					Operating cost			Total annual cost	Total hourly cost
			Depreciation 2/	Interest 3/	Insurance and taxes 4/	Rent 5/	Total	Power 6/	Maintenance	Total		
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1 spoolated conveyor and singulator 7/	2,000.00	8.3	240.00	50.00	80.00	-	370.00	8/ 7.25	40.00	47.25	417.25	0.209
1 electronic bloodspot detector unit	-	-	-	-	-	9/ 2,569.90	2,569.90	-	10/	-	2,569.90	1.285
4 egg grading benches 11/	1,600.00	8.3	192.00	40.00	64.00	-	296.00	9.67	20.00	29.67	325.67	.162
1 carton closer and packing table	-	-	-	-	-	324.00	324.00	19.34	50.00	69.34	393.34	.197
1 carton shaker	425.00	10.0	42.50	10.63	17.00	-	70.13	5.80	12.00	17.80	87.93	.044
43 ft. of gravity conveyor (wheel type)	215.00	8.3	25.80	5.38	8.60	-	39.78	-	10/	-	39.78	.020
Total											3,833.87	1.917

1/ Delivered plant cost.

2/ Based on company estimates of 10 percent per annum depreciation rate on the carton shaker and 1 percent per month on all other equipment.

3/ Interest at 5 percent of average investment (computed at 50 percent).

4/ Insurance and taxes assumed 4 percent of initial investment.

5/ Annual rate.

6/ 1956 rates, 1.45¢ per k.w.h.

7/ Including lighting equipment and multiple egg lifting device.

8/ Includes power for underlighting and electronic unit.

9/ First 10,000 cases at 10¢; next 10,000 at 8¢; all above 20,000 cases at 5¢, annual volume.

10/ Included in grading bench maintenance.

11/ Including 4 grading lights, carton chutes, egg flow diversion gates, carton and egg conveyor belt and motor drive unit.

Table 21.--Ownership and operating costs of flash candling and packing equipment based on a 4-man crew and 2,000 hours annual use, system B

Kind and amount of equipment	Initial cost 1/	Expected life	Ownership cost					Operating cost			Total annual cost	Total hourly cost
			Depreciation 2/	Interest 3/	Insurance and taxes 4/	Rent 5/	Total	Power 6/	Maintenance	Total		
	Dollars	Years	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
1 spoolated conveyor and singulator 7/ . . .	2,000.00	8.3	240.00	50.00	80.00	-	370.00	8/ 7.25	40.00	47.25	417.25	0.209
1 electronic bloodspot detector unit	-	-	-	-	-	9/ 2,569.90	2,569.90	-	10/	-	2,569.90	1.285
2 egg grading benches 11/	850.00	8.3	102.00	21.25	34.00	-	157.25	5.42	5.00	10.42	167.67	.084
1 carton closer and packing table	-	-	-	-	-	324.00	324.00	19.34	50.00	69.34	393.34	.197
1 carton shaker.	425.00	10.0	42.50	10.63	17.00	-	70.13	5.80	12.00	17.80	87.93	.044
43 ft. of gravity conveyors (wheel type) . .	215.00	8.3	25.80	5.38	8.60	-	39.78	-	10/	-	39.78	.020
Total . . .											3,675.87	1.839

1/ Delivered plant cost.
2/ Based on company estimates of 10 percent per annum rate on the carton shaker and 1 percent per month on all other equipment.
3/ Interest at 5 percent of average investment (computed at 50 percent).
4/ Insurance and taxes assumed 4 percent of initial investment.
5/ Annual rate.
6/ 1956 rates, 1.45¢ per k.w.h.
7/ Including lighting equipment and multiple egg lifting device.
8/ Includes power for underlighting and electronic unit.
9/ First 10,000 cases at 10¢; next 10,000 at 8¢; all above 20,000 at 5¢, annual volume.
10/ Included in grading bench maintenance.
11/ Including 2 grading lights, carton chutes, egg flow diversion gates, carton and egg conveyor belt and motor drive unit.

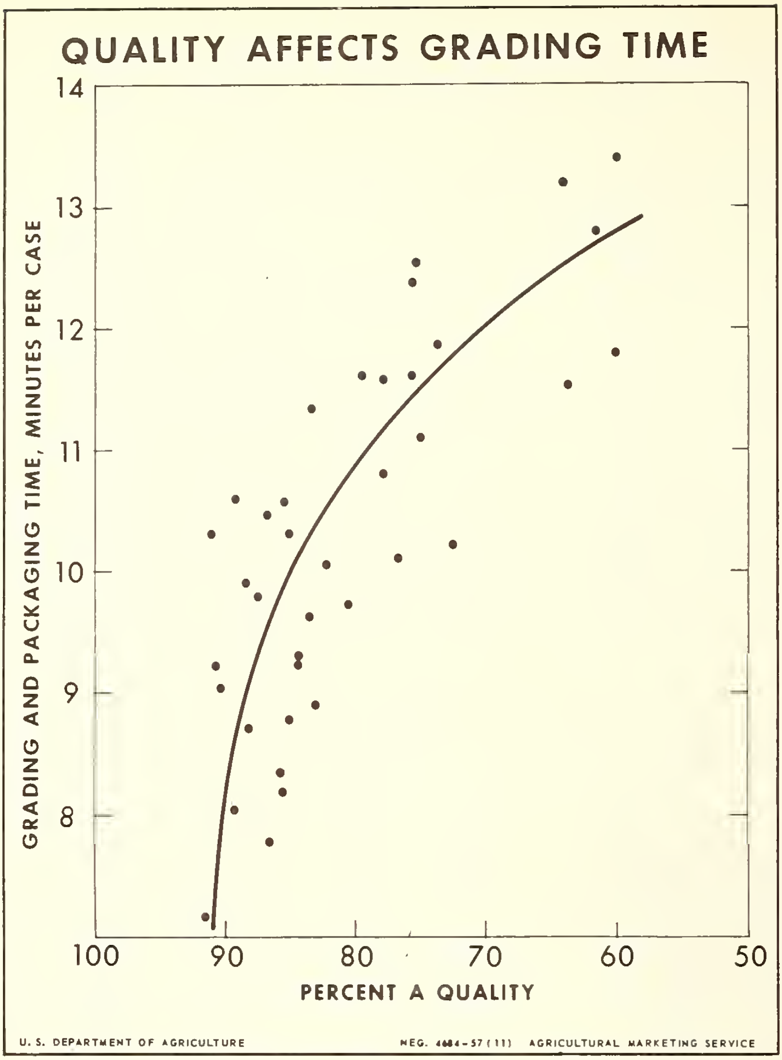

Figure 29.

Egg Marketing Terminology

Blind check. An egg with a cracked shell that can be detected best by illuminating the interior of the egg.

Bloodspot. An egg containing a bloodspot 1/8" in diameter or larger.

Bulk pack. A method of packing in which graded eggs are packed into filler-flats rather than into cartons.

Flash candling. Segregating obvious undergrade and reject eggs from a multiple group arrangement of eggs on a conveyor that rotates them under and over lighted areas of the conveyor. This procedure was requisite to system B for removing stained shells that might be missed by the grader, opaque eggs that might be missed by the detector and eggs with defectiv shells too weak to stand the rapid mechanical handling in the system.

Full candling. The manual examination of individual eggs for the purpose of determining their interior condition and quality by twirling each egg before a candling light (fig. 30).

Grading. Sorting eggs according to quality by the use of a candling light. The examination for sorting involves a cursory inspection of the shell and a careful inspection of the content for quality defects (fig. 30). It also generally involves sorting as to size but in this study all eggs had been mechanically sized on the farm, so sizing was unnecessary.

Packaging. The placing of eggs into either cartons or filler-flats at the time of segregation in the grading or flash candling operation. This is essentially cartoning work but in this study the term "packaging" is used in lieu of "cartoning" in order to avoid excluding the filler-flats packaging job from consideration by the limitation of an operation title.

Packing. Placing packaged eggs (in cartons or filler-flats) into cases and obtaining, opening, and closing the cases used.

Packing materials.

Chipboard carton; A paper board container that holds one dozen eggs in 2 rows of 6 eggs each, for consumer use. Preparing the container for use involves removing the collapsed cartons from fiberboard shipping containers

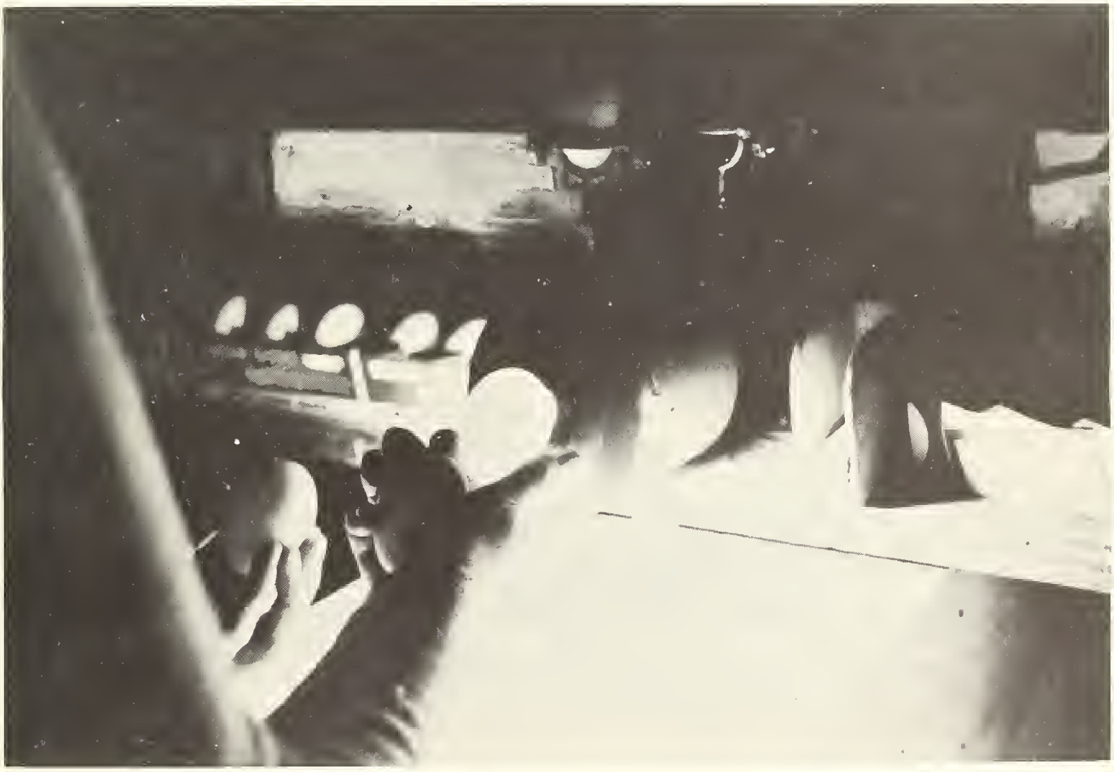

Figure 30.--The egg in position before the candling light.

(250 cartons per container) and placing them into a setup machine prior to distribution to packaging stations.

Molded pulp carton; a container that holds one dozen eggs in 2 rows of 6 eggs each, for consumer use. Preparing the container for use involves removal from a paper wrapper and placing one bunder (250 cartons) at a time into a shaker in order to disengage one carton from the other.

Egg case: A corrugated or solid fiber container holding 30 dozen chicken eggs. Each container has a center portion and 4 nondetachable cover flaps.

Filler-flat: A molded pulp egg tray with 30 cells arranged in 6 rows of 5 cells each, formed by the posts or prongs.

Opaque eggs. Reject eggs in which the egg white is diffused with blood to the extent that the transmission of light through the egg is reduced in intensity to a point insufficient to be picked up by the electronic detector.

Reject eggs. Eggs that are smashed, rotten, or contain bloodspots 1/8-inch or larger or that contain bloody whites.

Transfer eggs. The removal of 30 eggs at a time from an egg case, either by using the filler-flat in which they rest as a carrier or by a multiple egg lifting device that lifts the eggs clear of the case. In either case they are moved to and placed on a receiving surface such as the conveyors serving systems A and B.

Undergrade eggs. Eggs in the lower quality bracket, such as C quality, dirty, check or leaker. Eggs of these qualities were usually packaged in filler-flats. Eggs in the upper quality levels, B quality and better were packaged in cartons. The quality and grade terminology is based on the U. S. Department of Agriculture standards.

Ungraded eggs. Eggs that have been packed without regard to quality or size. In this study eggs had been sorted into size classes prior to reaching the plant.

Industrial Engineering Terminology

Base time. The observed time for an operation or an element of an operation, adjusted to allow for differences in rate of worker activity. The adjustment is known as a leveling factor and is expressed as a percentage of the observed time. It is based on the observer's judgment of a normal work pace.

Elapsed time. The length of time in hours and fractions thereof from the beginning to the end of an operation or cycle of operations.

Fatigue allowance. Although this factor is difficult to determine through any nonlaboratory technique, sound judgment of an experienced observer can translate the mental or physical stresses of a job into a fatigue factor. The allowance established is used as one of the adjustments applied to the base time for the element being studied in order to arrive at the productive time for a work element.

Element. A definable segment of an operation.

Grading labor. Labor involved in the examination for and determination of egg quality by the manipulation of individual eggs before a candling light or viewing groups of eggs over a flash candling device and disposing of the eggs handled into appropriate containers.

Personal allowance. An adjustment factor taking into account the time a worker spends away from his work station to take care of personal needs. The allowance is applied to the base time in order to arrive at the productive time for the work element.

Productive time. The base time required for performing a work element adjusted for fatigue and personal allowances.

Singulator. A device in system B that changes the arrangement of the egg position pattern on the spoolated conveyor from six abreast to single file as the flow of product makes a right angle turn en route to the detecting device and grading stations.

Spoolated conveyor. A conveyor having a series of one inch rods with rubber coated surfaces spaced on 1-3/4 inch centers. Each rod has six equally spaced concave areas for receiving individual eggs. The recesses in each spool prevent eggs from creeping toward the side of the conveyor as they roll on their short diameter with the forward motion of the conveyor.

Time study. A procedure for determining the amount of time required for the various components of a human activity by analyzing its individual elements as they are performed, and determining the time required for each. The determinations include time measurement of both the active and idle periods involved.

Time item. An element or group of elements.

Unit load. A number of cases of eggs stacked on a hand truck, pallet or skid in such a manner that they can be transported and/or stored as a single unit.

Unproductive labor. The labor potential that is idle under normal operating conditions while a crew member(s) waits for another crew member(s) or machine(s) to complete an operation cycle of a job.

Wait time. Idle time due to improper crew balance, undersupply of materials, machine breakdown or any combination of these inherent to or normal in an operation.

Productive Time Data

Fatigue and personal allowances for performing various operations in egg grading and packing plants are shown below:

Time item	Allowances Fatigue Percent	 Personal Percent	 Total Percent
Divert full cases from belt conveyor onto roller conveyor and push into position	10	5	15
Obtain full cases from conveyor, below waist height	10	5	15
Place full cases onto conveyor below waist height or stack 4 cases high onto skid.	10	5	15
Obtain empty cases from conveyor or 5-high stack	5	5	10
Place empty cases onto conveyor at shoulder height.	5	5	10
Open cases.	5	5	10
Close cases	5	5	10
Remove top flats from cases	5	5	10
Position top flats in cases	5	5	10
Obtain and position empty flats for undergrade and reject eggs	5	5	10
Stack empty flats	5	5	10
Collect empty flats	5	5	10
Transfer flat load quantities of eggs from cases to cross-feed conveyor. .	5	5	10
Transfer eggs to infeed conveyor by spring lifter.	10	5	15
Flash candle eggs on conveyor and remove undergrade and reject eggs. .	15	5	20

Continued

Fatigue and personal allowances for performing various operations in egg grading and packing plants--Continued

Time item	Allowances Fatigue Percent	 Personal Percent	 Total Percent
Remove eggs from detector reject tray and pack into flats.	10	5	15
Collect flat loads of undergrade and reject eggs	5	5	10
Place flat loads of eggs into cases	5	5	10
Obtain bundles or boxes of cartons from temporary storage.	10	5	15
Remove wrappers from bundles of cartons . . .	5	5	10
Open boxes of cartons.	5	5	10
Fold and dispose bundle wrappers.	5	5	10
Dispose of empty carton boxes	5	5	10
Place bundles of cartons into vibrator. . . .	10	5	15
Place cartons into carton forming machine . .	10	5	15
Place molded pulp cartons onto temporary storage shelf.	10	5	15
Place chipboard cartons onto temporary storage shelf.	5	5	10
Load cartons into carton supply chutes. . . .	10	5	15
Close and open egg flow diversion gates at grading benches.	5	5	10
Grade eggs.	15	5	20
Transfer eggs from receiving tray to cartons.	10	5	15
Push full cartons onto belt and position empty cartons on shelf	5	5	10
Pack cartons of eggs into cases	10	5	15
Walk and carry empty cartons, empty cases, or flat loads of eggs	10	5	15
Walk empty.	5	5	10

Labor requirements per 100 case equivalent for performing grading, supplying, and packing operations at system A using 30-dozen fiber cases, filler-flats, and molded pulp cartons 1/

Time item	Base time Man-hours	Fatigue and personal allowances Man-hours	Productive time Man-hours
Full case supplying			
Divert full cases to conveyor supplying grading line	0.14	0.02	0.16
Flat transferring			
Handle full cases:			
Obtain cases from conveyor and place on bench	.10		
Open cases.	.10		
Total full case handling labor.	.20	.03	.23
Remove top flats.	.05	.01	.06
Transfer flat loads of 30 eggs each onto crossfeed conveyor.	.60	.06	.66
Handle empty cases:			
Close cases	.10		
Place cases onto conveyor to packing table or beside under-grade and reject packing bench .	.05		
Total empty case handling labor	.15	.02	.17
Collect and dispose 1,400 empty flats.	.10	.01	.11
Walk between crossfeed conveyors. .	.58	.06	.64
Carton supplying			
Handle bundles of cartons:			
Obtain bundles of cartons from temporary storage at shaker (3,000 cartons).	.01		
Open bundles.	.04		
Dispose of bundle wrapers	.03		
Place compressed bundles of cartons into vibrator.	.02		
Place decompressed bundles of cartons onto temporary storage shelf.	.03		
Total bundle handling labor . .	.13	.02	.15
Load carton chutes:			
Walk to chutes.	.08		
Load chutes.	.03		
Total chute loading labor. . . .	.11	.02	.13
Walk from carton chutes to make up area.	.08	.01	.09

See footnote at end of tabulation.

Labor requirements per 100 case equivalent for performing grading, supplying, and packing operations at system A using 30-dozen fiber cases, filler-flats, and molded pulp cartons 1/--Continued

Time item	Base time Man-hours	Fatigue and personal allowances Man-hours	Productive time Man-hours
Undergrade and reject packing			
Handle empty cases:			
Obtain cases	0.08		
Open cases	.08		
Total empty case handling labor.	.16	0.02	0.18
Collect and pack undergrade and reject eggs:			
Collect flat loads of eggs from grading benches.	4.90		
Place flat loads into cases . . .	.98		
Place top flats into cases. . . .	.08		
Total undergrade and reject collecting and packing labor .	5.96	.60	6.56
Handle full cases:			
Close cases.	.08		
Place cases onto skid.	.08		
Total full case handling labor .	.16	.02	.18
Grading and packaging			
Grade eggs:			
Large eggs 60 to 80 percent A quality	18.17	3.63	21.80
Large eggs 80 to 100 percent A quality	14.15	2.83	16.98
Push full cartons onto belt and place empty cartons onto shelf. . .	1.95	.20	2.15
Stack 1,200 empty flats for disposal by flat loader.	.26	.03	.29
Position empty flats for undergrade and reject eggs	.90	.09	.99
Carton packing			
Handle empty cases:			
Obtain cases from conveyor	.12		
Open cases	.10		
Total empty case handling labor.	.22	.02	.24
Pack cartons into cases.	1.30	.20	1.50
Handle full cases:			
Close cases.	.18		
Place cases onto conveyor.	.08		
Total full case handling labor .	.26	.03	.29

See footnote at end of tabulation.

Continued

Labor requirements per 100 case equivalent for performing grading, supplying, and packing operations at system A using 30-dozen fiber cases, filler-flats, and molded pulp cartons 1/--Continued

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1/ Labor requirements for supplying chipboard cartons are as follows:

Time item	Base time Man-hours	Fatigue and personal allowances Man-hours	Productive time Man-hours
Carton supplying			
Handle boxes of cartons:			
Obtain boxes of cartons from temporary storage at carton forming machine (3,000 cartons)...	0.02		
Open boxes	.02		
Dispose of empty boxes	.01		
Total box handling labor	.05.	0.01	0.06
Place cartons into carton forming machine	.10	.02	.12
Place formed cartons onto temporary storage shelf	.36	.04	.40
Load carton chutes:			
Walk to chutes	.28	.04	.32
Load chutes.	.43	.06	.49
Total chute loading labor.	.71	.10	.81
Walk from carton chutes to make up area	.28	.03	.31

Labor requirements per 100 case equivalent for performing grading, supplying, and packing operations at system B using 30-dozen fiber cases, filler-flats and molded pulp cartons 1/

Time item	Base time Man-hours	Fatigue and personal allowances Man-hours	Productive time Man-hours
Full case supplying			
Divert full cases to conveyor supplying grading line.	0.11	0.02	0.13
Flat transferring and flash candling			
Handle full cases (obtaining cases):			
Pull cases onto bench.	.15		
Open cases	.11		
Total full case handling labor .	.26	.03	.29
Remove empty flats	.49	.05	.54
Position empty flats for undergrade and reject eggs	1.20	.12	1.32
Transfer eggs onto infeed conveyor and remove undergrade and reject eggs.	1.41	.21	1.62
Flash candle and place undergrade and reject eggs into filler-flats .	2.65	.53	3.18
Pack undergrade and reject eggs:			
Place flat loads of eggs into cases	.47		
Place top flats into cases	.08		
Total undergrade and reject egg packing labor	.55	.06	.61
Handle full cases (disposing cases):			
Close cases.	.08		
Stack cases on skid.	.08		
Total full case handling labor .	.16	.02	.18
Handle empty cases:			
Close cases.	.08		
Place cases on conveyor to packing table	.04		
Total empty case handling labor.	.12	.01	.13
Dispose 1,400 empty flats.	.02		.02
Carton making and supplying			
Handle bundles of cartons:			
Obtain bundles of cartons from temporary storage at shaker (3,000 cartons)	.01		
Open bundles	.04		
Dispose of bundle wrappers	.03		
Place compressed bundles of cartons into vibrator	.02		
Place decompressed bundles of cartons onto temporary storage shelf	.03		
Total bundle handling labor	.13	.02	.15

See footnote at end of tabulation.

Continued

Labor requirements per 100 case equivalent for performing grading, supplying, and packing operations at system B using 30-dozen fiber cases, filler-flats, and molded pulp cartons 1/--Continued

Time item	Base time Man-hours	Fatigue and personal allowances Man-hours	Productive time Man-hours
Load carton chutes:			
Walk to chutes	0.06		
Load chutes.	.03		
Total chute loading labor. . . .	.09	0.01	0.10
Walk from carton chutes to make up area.	.05	.01	.06
Grading and packaging			
Grade eggs:			
Large eggs 60 to 80 percent A quality..	14.87	2.97	17.84
Large eggs 80 to 100 percent A quality	13.60	2.72	16.32
Push full cartons onto belt and place empty cartons on shelf. . . .	1.73	.17	1.90
Close and open egg flow control gate	1.05	.11	1.16
Position empty flats for undergrade and reject eggs	.90	.09	.99
Packaging eggs			
Transfer eggs from receiving tray to cartons	5.37	.81	6.18
Transfer eggs from receiving tray to flats	9.12	1.37	10.49
Push full cartons onto belt and place empty cartons on shelf. . . .	1.73	.17	1.90
Close and open egg flow control gate	1.05	.11	1.16
Position empty flats for undergrade eggs.	.90	.09	.99
Undergrade and reject packing			
Handle empty cases:			
Obtain cases	.08		
Open cases	.08		
Total empty case handling labor.	.16	.02	.18
Collect reject eggs:			
Position empty flats at detector reject tray	.90		
Transfer eggs to flats	7.00		
Total reject collecting labor. .	7.90	.79	8.69

See footnote at end of tabulation.

Continued

Labor requirements per 100 case equivalent for performing grading, supplying, and packing operations at system B using 30-dozen fiber cases, filler-flats, and molded pulp cartons 1/--Continued

Time item	Base time Man-hours	Fatigue and personal allowances Man-hours	Productive time Man-hours
Collect undergrade eggs from grading benches	2.02	0.20	2.22
Pack undergrade and reject eggs:			
Place flat loads into cases. . . .	.98		
Place top flats into cases	.08		
Total undergrade and reject packing labor	1.06	.11	1.17
Handle full cases:			
Close cases.	.08		
Stack cases on floor	.08		
Total full case handling labor .	.16	.02	.18
Walk from packing station to detector reject tray.	.95	.10	1.05
Carton packing			
Handle empty cases:			
Obtain cases from conveyor	.12		
Open cases	.10		
Total empty case handling labor.	.22	.02	.24
Pack cartons into cases.	1.30	.20	1.50
Handle full cases:			
Close cases.	.18		
Place cases onto skid.	.08		
Total full case handling labor .	.26	.03	.29
Supply empty cases to undergrade and reject packing bench.	.08	.01	.09

See footnote at end of tabulation.

Continued

Labor requirements per 100 case equivalent for performing grading, supplying, and packing operations at system B using 30-dozen fiber cases, filler-flats, and molded pulp cartons 1/--Continued

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1/ Labor requirements for supplying the equivalent of 100 cases of chipboard cartons are as follows:

Time item	Base time Man-hours	Fatigue and personal allowances Man-hours	Productive time Man-hours
Carton supplying			
Handle boxes of cartons:			
Obtain boxes of cartons from temporary storage at carton forming machine (3,000 cartons)...	0.02		
Open boxes	.02		
Dispose of empty boxes	.01		
Total box handling labor	.05	0.01	0.06
Place carton into carton forming machine	.10	.02	.12
Place formed cartons onto temporary storage shelf	.36	.04	.40
Load carton chutes:			
Walk to chutes	.17	.03	.20
Load chutes.	.43	.06	.49
Total chute loading labor.	.60	.09	.69
Walk from carton chutes to make up area.	.13	.01	.14

Table 22.--Labor required by 1 worker to prepare and distribute the equivalent of 100 cases of chipboard cartons; system A 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Productive labor:		
Handle boxes of cartons	0.06	2.7
Place cartons into carton forming machine	.12	5.3
Place cartons onto shelf	.40	17.7
Walk to and load carton chutes	.81	35.8
Walk empty	.31	13.7
Total productive labor	1.70	75.2
Unproductive labor:		
Wait on carton machine	.56	24.8
Total labor	2.26	100.0

1/ Actual production rate of cartoned eggs averaged 2,800 dozen per 100 cases of ungraded input (2.11 man-hours).

Table 23.--Labor required by 1 worker to prepare and distribute the equivalent of 100 cases of chipboard cartons, system B 1/

Time item	Labor required	Percentage of total labor
	Man-hours	Percent
Productive labor:		
Handle boxes of cartons	0.06	3.0
Place cartons into carton forming machine	.12	6.1
Place cartons onto shelf	.40	20.3
Walk to and load carton chutes	.69	35.1
Walk empty	.14	7.1
Total productive labor	1.41	71.6
Unproductive labor:		
Wait on carton machine	.56	28.4
Total labor	1.97	100.0

1/ Actual production rate of cartoned eggs averaged 2,750 dozen per 100 cases of ungraded input (1.80 man-hours).

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